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GOthic SUBURBAN COTTAGE.

[See page 235.]

THE  
AMERICAN COTTAGE BUILDER:

A SERIES OF

DESIGNS, PLANS, AND SPECIFICATIONS,

FROM \$200 TO \$20,000,

FOR

HOMES FOR THE PEOPLE.

TOGETHER

WITH WARMING, VENTILATION, DRAINAGE, PAINTING, AND  
LANDSCAPE GARDENING.

BY JOHN BULLOCK,

ARCHITECT, CIVIL ENGINEER, MECHANICIAN, AND EDITOR OF "THE RUDIMENTS OF  
ARCHITECTURE AND BUILDING," ETC., ETC.

*Illustrated by Seventy-five Engravings.*

PHILADELPHIA:  
HENRY CAREY BAIRD & CO.,  
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1876.

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## P R E F A C E.

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THE object of this work is to furnish designs of cottages, from a twenty-five dollar cottage to a twenty-five thousand dollar palace—giving estimates as to cost, furnishing plans and specifications, and treating upon the rudiments of the Arts called into exercise by the practice of Cottage Building.

This book being the third of the "Architectural Series," the portions of the two former volumes, which might properly be incorporated in this, are omitted. The first of the series is "The History and Rudiments of Architecture;" the second, "Rudiments of the Art of Building."\*

The chapter on WARMING AND VENTILATION is edited from Tomilson, and that on GARDENING, from Glenny. Wherever, in other portions of the work, we have availed ourselves of the labors of others, we have given them proper credit.

Although the book is intended to be of a practical character, I thought it not improper, in the chapter entitled "GENERALLY," to show the position and the difficulties of the Artist. In that chapter, and the one entitled "THE ARTIST'S CALLING," I have discussed Arts and Artists, and their influence on the progress

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\* These two books are now published in one volume.

PREFACE.

of civilization, giving to them their proper position as a motor, rather than an attendant of Progress. I hold that the Architect, to attain eminence in his calling, *in this age*, must recognize and act upon the principles there inculcated

JOHN BULLOCK.



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## CHAPTER XXI.

## ARTIST'S AND ARTISAN'S CALLING.



# THE AMERICAN COTTAGE BUILDER.

## CHAPTER I.

### GENERALLY.

TO DECIDE *where* to build a cottage is quite as difficult a task as to tell *how* to build it. The location of a house adds as much to its beauty and convenience, as does its style or arrangement. The bird which builds its nest, is one of nature's own Architects, and practices its truest art. It first seeks a proper locality, and usually selects



a place at such an height from the ground as to be secure from disturbing animals. It builds in the fork of a tree, or the beams of a barn, so as to be unlikely to be moved by the winds; it seeks protection from the storms under the overhanging leaves, the roof of the barn, or perhaps the thatch on the hay-

stack; and thus it is that the bird shows its architectural skill in selecting a spot *where* to build a home. For the purposes for which the bird desires to use its nest, for the objects which it wishes to gain, it perfectly adapts its means to its end.

We do not understand the object of Architecture to be to tell the bird that he should no longer be a bird living in trees, or to say to the monks on Mont Blanc, "your location is bad, cold, dreary and uninviting." Neither is it her province to say to the rustic, "thou should'st be a civilian;" or to the civilian, "thou should'st seek a rural home;" or even to the savage, "thou should'st build a house after the manner of the civilized nations."

The Architect must first know the *objects* desired, before he can decide as to the proper locality or style. He comes to the monks of St. Bernard, and they say, "we wish to stay on Alpine heights, amid continued storms and eternal snow, to practice the rites and to perform the duties of our holy religion, and relieve the suffering and weary that pass this way." Some men might answer that more good could be done in other localities, or in the practice of other religions. Not so the true Architect. He seizes upon the monk's aspirations and desires, selects a locality as near as practicable to where the passing traveler would be exposed to the most hardships and dangers, and be most likely to need assistance. He then, in that same vicinity, selects the spot least exposed to the storms and the tempests, and commences his edifice.

Thus it is, that the desired object or end must first be made known to the Architect, and it is then his province to practice that peculiar and God-like attribute of seeing the end from the beginning, and adapting his means to the consummation of his purpose. It is not Architectural to say to the residents of the granite hills of New Hampshire, "you can find a more pleasant home, a more beautiful and rural residence in the everglades of Florida;" or to say to the gold-seeker upon the banks of the Sacramento, "more beautiful, pleasant and commodious is the cottage home of your mother, on the banks of the St. Lawrence." But it is Architectural, to go to the granite hills and build for its residents homes convenient for the objects which its



occupants shall desire, and easy of access to and for the business which each has decided for himself to pursue.

Every nation and people have some peculiar systems or principles of government, of ethics, of religion, which form a part of the public mind, morals and sentiments. They control and subdue the passions, the aspirations and the desires; they develop themselves, in a more or less modified form, in every feature and ramification of society; in modes of living, and in the Architecture of the country. The Architects, the Painters and the Sculptors of former ages and countries, have developed these feelings, in most instances, in a perfect manner. We say *perfect*, not because the principle or religion developed was perfect, but because it was fully and perfectly made manifest and shown. Take, for instance, Angelo's painting of *The Last Judgment*—in which, by the side of the Supreme Judge and his angels, sits the Blessed Virgin. The Infidel may say there is no last judgment, and the Protestant will say that Mary will at that day be like any other creature; but not so thought Angelo—not so thought the Catholic world, at that time; and Catholics, Protestants and Infidels, all agree that Angelo was one of the greatest and truest Artists that ever lived.

Thus we see that the productions of great minds, in one country or age, copied by another, are far from being proofs of the greatness of him who copies them. The man who, in the American Senate, should repeat Demosthenes' greatest oration, instead of proving himself a statesman, would show himself a fool. The Architect that copies a Greek or Roman edifice for an American occupant, shows himself less than an artist. The peculiarities of the American people, their desires, their occupations and wants, must first be apprehended and understood, before any Architect, however great, can successfully and truly become an Architect for America. No man has contributed more to the true Architecture of the country than the lamented DOWNING: possessing at once the genius of the artist, the knowledge and

skill of the mechanic, and the spirit of the people, he corrected and improved the popular taste for rural homes. He was a perfect artist, and his death, in early manhood, was a national bereavement ; but his fame was firmly established ere he died, and his memory will ever remain green in the affectionate remembrances of his countrymen.

In Catholic churches, where the celebration of the mass is the chief feature of public worship, the altar is justly and properly the most prominent thing in the church : built of the most costly material—of the finest workmanship—the most expensively ornamented—the most easily observed from every part of the building. This is correct. It gives expression to the ruling idea in the Catholic's mind. The Protestant may ridicule it, but the Architect designs for *him* the simple lectern or the elevated pulpit, all in consonance with *his* creed. Did the Architect do less than this, he would be virtually saying, "be no longer a Catholic," or, "be no longer a Protestant." True, if it be the Architect's desire to cripple the expression of the Catholic or Protestant mind—if that be the object—he can do it, and do it artistically ; but that is never required. Neither Catholics nor Protestants want their churches built so as to cripple a fair expression of their respective creeds, and neither Protestants nor Catholics build churches for each other.

As it is with churches, so is it with cottages. The purposes for which the house is desired, the character and sentiments of the surrounding people, the surrounding scenery, the conveniences of water, drainage, &c., are all to be considered and understood, before any directions can be given where or how to build a cottage. In our descriptions of different plans, we shall speak more in detail of each of these subjects, with special reference to each particular case.

## CHAPTER II.

## THE VARIOUS PARTS.

## WALLS.

The *Walls* of cottages may be formed of a great variety of materials, and the nature of the material used is a fertile source of variety and beauty. As a general principle, it may be remarked that the walls of a cottage should always be built of the materials furnished by the soil or vicinity where it is situated; for in almost every part of the world the *cheapest* substance for building walls is taken from the earth or other substance on which they are to be built.

In all countries where *wood* abounds it will be found the cheapest, and also a very suitable material for building. The common objection, its want of durability, may be in a great degree remedied by raising footings of masonry or brickwork, or even by forming a platform of dry earth or rubbish, as a basement for the frame-work of the walls; and by having the timber well seasoned.

The employment of different kinds of *earth* for constructing walls, dates from a very early period, and has been used by nearly all nations. Some houses have lately been pulled down which the title-deeds show to have been nearly 200 years old. The cob-walls of Devonshire have been known to last above a century without requiring the slightest repair; and the Rev. W. T. ELICOMBE, who has himself built several houses of two stories with cob-walls, says, that he was born in a cob-wall parsonage, built in the reign of Elizabeth, or somewhat earlier, and that it had to be taken down to be rebuilt only in the year 1831.

*Earths* of different kinds may be formed into walls in either of the three following modes, viz:--In the *Pisé* manner, by lumps moulded in boxes, and by compressed blocks

The *Pisé* appears to be the best method of forming walls of earth, and if carefully executed, is one of the warmest, driest, and most durable that can be erected, and at the same time one of the cheapest. *Pisé* is a peculiar mode of forming buildings, particularly those of cottages with some sort of stiff, earthy materials of a loamy quality.

Various modes of forming these walls have been given by different writers: the following appears, however, to contain most of the advantages sought for.

Gravel is the best sort of earth for this kind of walling, and it should be of a loamy nature, with a large proportion of stones. It should be used as dry as possible, no cement being required, as it is held together by the force of cohesion alone. For a sample of the gravel wall, see the chapter on Octagon Houses.

The foundation upon which *Pisé* walling is to be erected is formed of stone or brickwork, rising not less than six inches or a foot above the surface of the ground, and about six inches wider than the thickness of the intended wall. It should be covered with a layer of Roman cement, stone, or tile, to prevent the rising of damp. The foundation being completed, frames formed of planks of any convenient length are fixed by resting them on the edges of the stone or brickwork, on either side; they are held together at the top and bottom by iron bolts, and kept apart at the top by pieces of wood called "guides," placed about three feet asunder. The *Pisé* gravel is then thrown in, about half a bushel at a time, spread evenly, and rammed down till the surface becomes perfectly hard. The work proceeds in this way till the frame is filled to within an inch or two of the upper bolts. A portion of the wall being thus completed, the lower bolts are drawn out and the upper ones slightly loosened: the frame is then raised bodily, till the lower holes

rise above the top of the wall; the bolts are then replaced, and, together with those at the top, screwed up, and the work is proceeded with as before.

One course may be raised upon another, as thus described, immediately it is finished; but it is found more convenient, and makes better work, to carry on the courses horizontally, and keep them of an equal height. As the work proceeds, the tops of the walls are kept dry by copings or other means; and when completed to the necessary height, the roof (which should be already framed and ready for fixing) is immediately put on and covered in.

The spaces for the doorways and windows are formed by placing partition boards, fastened to the frame-work by bolts, of the breadth of the wall and height of the frame, on either side of the space to be left vacant; and pieces of timber, two or three inches thick, shaped like truncated wedges, are then inserted, with their bases in the wall itself, and with their smaller sides touching the partition boards: to these timbers the door-posts and window-frames are afterwards fastened. If the building rises above a ground story, sleepers or plates are laid on the inner side of the walls, as in the ordinary manner, for the floor joists to rest upon.

It has not been thought necessary to give drawings or particular descriptions of the frame-work and implements used in the formation of *Pisé* walling, as they are probably as well known as any other of the implements used in the Builder's art: a slight improvement, however, would be effected in the construction of the frame-work by doing away with the wooden guides, and by altering the form of the bolts.

The above method of forming *Pisé* walling is different from the mode of building common in Devonshire and the West of England, and known by the name of *cob-building*, as will be seen, and is greatly superior to it, and far more durable.

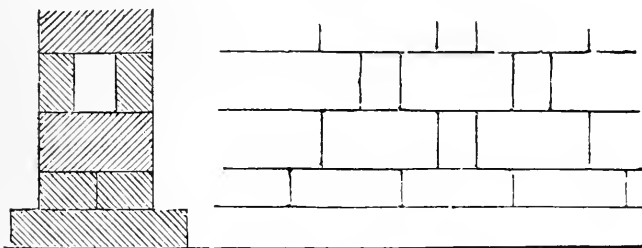
The substance of which *cob*-walls are made, is loam or clay mixed with straw and moistened with water; it is formed in frames, in the same way as that above mentioned, but in courses of not more than one foot or one foot and a half in height; it is then left some time to dry and become consolidated, before a second course is imposed. The window and door-frames are inserted as the work proceeds, and their respective openings cut out after the work is finished. The strength and solidity of cob-walling depends much upon its not being hurried in the process of forming; and, when finished, it must be left some months to dry and settle.

*Mud* walls, or walls of clay lumps, are thus formed: The clay to be used is first freed from all large stones, and soaked with as much water as it will absorb; it is then well beaten, and a quantity of short old straw added, and the whole well and thoroughly mixed up together. The mixing should be continued by the treading of horses, or otherwise, till the clay becomes thoroughly broken, and about the consistence of mortar: it is then put into moulds, 18 inches long, 12 inches wide, and 6 inches deep, without a bottom, and moulded in the same manner as bricks. These lumps are then dried in the sun, and laid in the usual manner with mortar. For a sample of the mud or unburnt brick wall, see the Chapter on *Prairie Cottages*.

As *brickwork* is so general in its application, and as the price only stands in the way of its still more universal adoption, it may be useful to describe the methods usually employed in building *hollow walls* of brick, and thus to economize material.

Silverlock's hollow walls are constructed of bricks set on edge, each course consisting of an alternate series of two bricks placed edgewise, and one laid across; forming a thickness of 9 inches, and a series of cells, each cell 9 inches, in the lengthway of the wall, 4 inches broad, and  $4\frac{1}{2}$  inches deep. The second course is laid in the same way, but

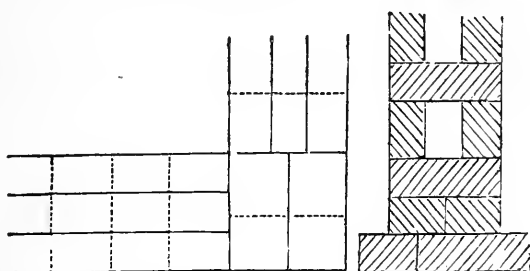
the position of the bricks alternate, or break joint with the first. This method differs from that of Dearne, described below, in being carried up in Flemish instead of English bond. It is represented in section and elevation in the adjoining figures.



Section of Silverlock's hollow wall, 9 inches thick.

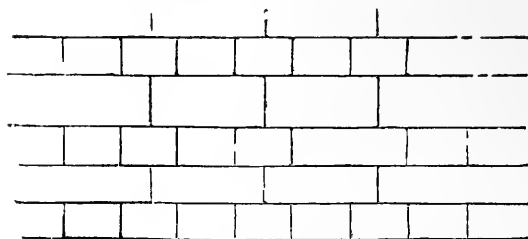
Elevation.

Another method of building hollow brick walls is that of Mr. Dearne, in which the lower courses, up to the level of the floor, are formed in English bond. The next course consists of a series of stretchers, on edge on each side, thereby leaving a hollow space throughout the length of the wall; the next course is a row of headers, laid flat; and the same system is continued throughout. The figures represent a plan, section, and elevation of the wall.



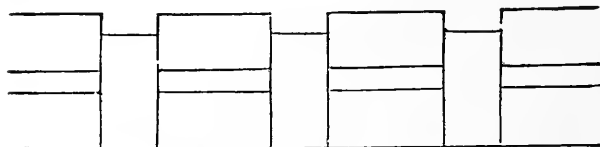
Plan of Dearne's hollow brick wall, 9 inches thick.

Section.



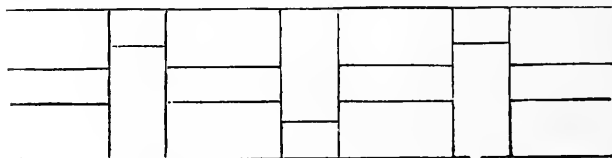
Elevation.

Mr. Loudon has proposed a method of building hollow walls 11 inches wide, by keeping the headers or cross bricks 2 inches within the line of the stretching or lengthway bricks, and consequently the latter will be 2 inches apart along the centre of the wall. "Walls built in this way are handsome on the fair side; at least equally strong with solid walls, always dry, and less easily penetrated by cold in winter, or heat in summer. The inner surface, being uneven, is peculiarly favorable for receiving and retaining the plaster."



Loudon's hollow brick wall, 11 inches thick.

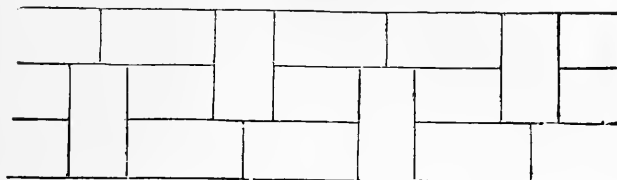
Another mode, 12 inches thick, is represented in the following engraving.



Hollow brick wall, 12 inches thick.



The following mode of building a hollow brick wall, 14 inches in thickness, requires but a few additional bricks to that required for a 9-inch solid wall. It is constructed as shown in the figure, which represents one course, the one above that being reversed.



Hollow brick wall, 14 inches thick.

In the chalk counties of England and elsewhere, the *flint-built* walls of the middle ages might be used. They are formed by building the flints up in frames, and pouring cement into the interstices. The cement employed may be composed of thoroughly burnt chalk, slaked with water, and mixed with two parts of rough sharp sand, and small sharp gravel-stones; the whole to be mixed up together while dry, and a sufficient quantity of water added to make it into a liquid paste. The foundations must be of brick or stone, and the roof should have a bold projection, to protect the walls from the rain. In this mode of forming walls are included all the small land-stones of a country, so far broken as to incorporate on the cementitious principle of construction.

The Roman circus at Toulouse, and the ancient castle at Hastings, besides many other buildings, are built of these materials, and have endured for centuries.

The following mode of constructing external walls of *framed timber*, *rubble*, and *plaster*, is common in and about Paris, and is described by Mr. Hosking:

The framed timber structure being completed, strong oak batten laths from 2 to 3 inches wide are nailed to the

quarters horizontally, at 4, 6, or 8 inches apart, according to the character of the work, and the spaces between are loosely built up with rough stone rubble. A strong mortar is then laid on at both sides at the same time, and pressed completely through from the opposite sides, so that the mortar meets and entirely embeds the stone rubble by filling up all the hollows, and with so much body on the surface as to completely cover up and embed the timber and laths.

Walls may be built of *hollow bricks*,\* which appear to have many advantages over those in common use. According to Mr. CHADWICK, they are superior to the common stone and brick construction—

In preventing the passage of humidity, and being drier.

In preventing the passage of heat, and being warmer in winter and cooler in summer.

In being a security against fire.

In preventing the passage of sound.

In having less unnecessary material, and being lighter.

In being better dried, and burnt harder and stronger.

In being more cleanly.

In being cheaper.

But however hollow bricks may answer for external walls, there can be no doubt of their applicability for inner partitions.

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\* It has been said that walls formed of hollow bricks are found to harbor insects; but this must be from faulty construction, as there seems no reason why a hollow wall of burnt clay should do so more than a hollow partition of timber and plaster.

It has been proposed to build the external walls of cottages and small houses as thin as  $4\frac{1}{2}$  inches, with hollow bricks. This is absurd, as no materials, however good or carefully put together, can retain warmth and prevent the passage of sound if built so slightly.

Mr. Loudon is probably correct in fixing the minimum thickness of external walls in this country, for human habitations, at 18 inches: but, indeed, nothing less than a series of experiments with walls of different materials and different thicknesses can satisfactorily determine these matters. Some singular and unexpected results would probably arise. A little money judiciously spent in making experiments of this kind would be of very great service.

The form represented in the annexed drawing (which may be readily made with any tile machine) might be tried. They might be built up dry, and cement in a liquid state poured in at the hollow space between them : quarters should be inserted on either side of doorways in angles and at distances of three or four feet.\*



Plan of hollow brick partition.

The common quarter partitions, if based on a brick wall may be rendered nearly fire-proof by brick-nogging them, especially if care be taken to fill in between the joists, over the partitions.

It has lately been proposed to use wire-work (galvanized or japanned to prevent corrosion), the wires being about  $\frac{1}{4}$  inch apart, in place of lath, for ceilings and partitions : this plan would of course greatly diminish the risk from fire.

The cheapest and one of the most useful *coverings* for the external walls of houses formed of earth, or indeed of any other material requiring to be covered, and having projecting eaves, is rough-cast. In the process of executing it, the wall is first pricked up with a coat of lime and hair, on which, when tolerably well set, a second coat is laid, as smooth as possible. As fast as the workman finishes this surface, another follows him with the rough-cast, with which he bespatters the fresh plastering, and smoothes it with a brush, so that the whole dries together. The rough-cast is a composition of small gravel, finely washed, mixed with pure lime and water to a state of semi-fluid consistency

For inside work, coarse stuff, or lime and hair, is prepared like mortar, with sand; but in the mixing, hair of the bullock, obtained from the tanners' yards, is added to it,

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\* Their most convenient size and least thickness must of course be a matter for experiment ; and the author would take this opportunity of saying that he has had no means of testing the efficiency of this or of any of the contrivances mentioned ; they must be considered, therefore, merely as suggestions

and distributed over the mass as equally as possible. Mere laying or rendering is, however, the most economical sort of plastering, and does very well for cottages.

The walls may be colored while the plaster is wet, on the principle of *fresco*: the colors, by this method, are fresher and more brilliant than by any other, and may be had at a very trifling expense.

But the commoner sorts of paper being now so cheap—and with greater simplicity of pattern, and by using but one color, they might be manufactured still cheaper—the walls of every cottage living-room, at least, should be covered with it, as conducing so much to the cheerfulness and comfort of the inmates.\*

#### FLOORS.

The *Floors* of cottages may be formed in a great variety of ways; the principal, and among the most economical, are the following:

*Lime-ash floors* are formed in several ways, according to the locality. One of the most approved methods is the following: the sand to be used, after being well washed and freed from earth, is mixed with lime ashes, in the proportion of two-thirds sand to one-third ashes, both thoroughly mixed together. It is then, after being suffered to remain for two

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\*The great beauty capable of being attained in a paper with but two colors (that is a ground color and a different one for the ornament) has been pointed out and illustrated by Mr. Pugin, but apparently to little purpose; for the most expensive modern papers consist of a set of unmeaning patterns, or direct imitations of flowers, animals, parts of buildings, &c., in as many colors as the price of the paper admits of, and commonly without the least regard to harmony of arrangement. Those who are unable to produce a beautiful and harmonious effect by the use of two colors, are not very likely to succeed by the use of ten or a dozen,—the difficulty of producing a fine and harmonious effect increasing in a geometrical ratio (as to speak) with every additional color employed.

or three days, tempered with water, and laid on the ground, or other surface to be covered, to the depth of about 3 inches. In two or three days it becomes sufficiently hard to bear treading on, and is then beaten all over with a wooden mallet, till it becomes perfectly hard, using at the same time a trowel and a little water to render the surface as smooth as possible. These floors are very durable, having been known to last for a number of years without any repair.

Another and very economical mode for ground floors is to lay on a hard and well beaten foundation, clean gravel, sand, lime, and tar, forming a *concrete*, and covering this with an inch and a half of good cement, composed of one part of cement to three parts of sand, carefully floated and troweled. These floors require to be executed with great care. \*

In using plaster or stucco for the upper floors, broad battens, or reeds, are laid on the joists (hoop-iron in lengths to stretch from wall to wall, would perhaps be found better): the upper surface or floor of plaster is then laid and finished as above described, and the ceiling completed between the joists. If the hoop-iron is quite straight and flat, and nailed here and there to the joists, close together, no plaster ceiling need be required, the under side being painted.



Section of plaster floor.

*Asphalte* has been much employed of late for the flooring of barns and outbuildings, as well as for pavements, roofs, &c., but does not appear to have been much used in cottages, for the floors of which it would seem to be admirably adapted, at least for rooms on the ground floor. It is laid down in the following manner: on a dry foundation a layer

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\* The above modes of forming plaster floors are given from a variety of methods practised in various places: many more might be mentioned, all said to be equally good and lasting; but without a trial there is no way of testing their merits, or of judging which is the best.

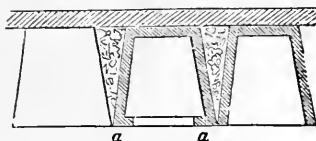
of gravel or small stones is laid, upon which the asphalt, in a boiling state, is evenly spread to a thickness of about 2 inches, being at the same time carefully pressed down and smoothed: very small stones are then sifted over, and pressed down on it.\*

As one principal object in the formation of floors in cottages on the ground story is to insure their dryness, † a method said to be practised in Bengal would seem to be very suitable in places where pottery is cheap. The earth of the room to be floored is made hard and level, and unglazed *earthen pots*, about a foot in height, are then placed with their mouths downwards and close together, over the whole surface: the vacant spaces between the pots are then filled in with pounded charcoal, and over the whole a floor is formed of coarse brick-dust and lime, well worked together. Common flower-pots would answer the purpose, as in the figure, but they would be better if made with a ledge, *a, a*, and thereby offer a much firmer resistance to the pres-

\* According to Dr. Ure, an asphalt equal to the natural kind is made by mixing boiled coal tar with powdered chalk or bricks.

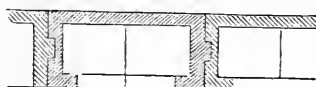
† The importance to health of living in a dry habitation is thus shown by Captain Murray, R. N., in a letter to a distinguished medical practitioner in Scotland. He says that he succeeded in bringing back to England the whole of his ship's crew without even one sick, after having passed two years among the icebergs of Labrador, and having gone from thence to the coast of Caraccas, and afterwards visiting the whole of the West India Islands and other places,—a severe trial to the constitutions of his men, in climates usually fatal to so many Europeans. And this he attributes principally to the dryness of his ship, to his having every part of it scrubbed daily with hot sand and holy-stones, and to the employment of Brodie stoves, which were constantly used until every appearance of humidity vanished. He says, "I am quite satisfied that a dry ship will always be a healthy one, in any climate." This, of course, must apply equally to houses. To insure dryness, therefore, as much as possible in places where the ground is low and damp, an artificial platform may be formed with dry brick or other rubbish, 18 inches or 2 feet above the level of the ground, and on this the cottage should be built.

sure above than the mere edge of the pot. The space between the pots may of course be filled in with any kind of dry rubbish, (charcoal being expensive,) and the floor formed of lime-ash, as is above described.



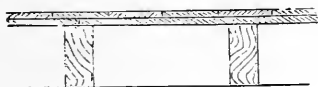
Section of a plaster floor.

A still firmer floor, and one needing no cement covering, might be formed by using *hexagonal pots* with a rim, as above mentioned, and a groove and tongue, which would bind the whole together, rendering any cement unnecessary. On a hard foundation, the under rim might, perhaps, be dispensed with.



Section of a floor formed of hollow pots.

The entrance porch, lobby, kitchen, wash-house, &c., may be paved with *brick, on edge*; and in the better sort of cottages, with ornamental *tiles*, set anglewise or square. These tiles may be considered to make the best sort of floors for cottages, as they are hard and nearly indestructible, readily cleaned, and remove all danger from fire. To their use on the ground floor there can be no objection but expense, and this would to a certain extent be removed by their more general use. They might also be readily employed in the upper floors by laying them on longer tiles, as seen in the drawing, and bedding them in cement, in the same way as the common plain tile floors are constructed. If only



Section of tile floor.

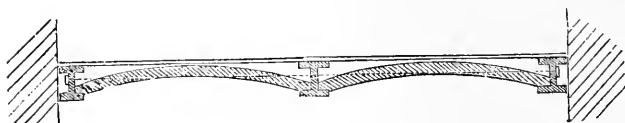
these latter are used, two courses would be enough for a bearing of two feet from centre to centre of the joists.

The upper floors of cottages have lately been executed of arched *brickwork* in mortar. The arches (in one case) were seven feet span, and turned in half a brick, except at the springing and the skew-backs; they rose about one

inch in every foot in span; the spandrils were filled in with concrete, and the tile floor afterwards laid with mortar.

Instead of brickwork, arches formed of *hollow pots* have been proposed, which are much lighter.

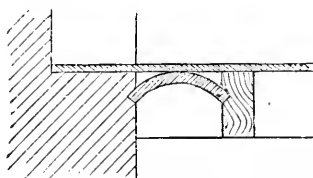
The annexed drawing represents a section of a *fire-proof floor* formed of iron bearers with brick or hollow pot arches: one or two rods might be necessary to prevent lateral



Section of fire-proof floor.

thrust, and to make the floor perfectly independent of the walls, except where the bearers rest on them. Either a plaster, tile, or wooden floor might be laid on it.

The subjoined engraving represents the opening for the

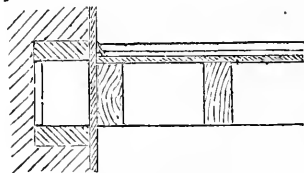


Section of tile-trimmer.

fire-place, with a slab for the hearth and trimming joists; and instead of an arch in brickwork, as usual, a series of curved tiles. This, it will be seen, must answer all

the uses which the ordinary brick trimmer is supposed to possess, would be neater, and would require much less labor in the fixing.

As the firmness and stability of a brick or stone wall depends so much on its being built without the admission of any

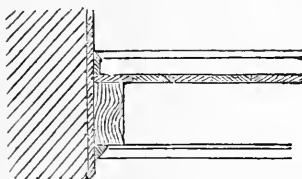


Section of girder floor.

other material, such as wood for plates, &c., and on its having as few points as need be for the support of the floors, a great improvement would be effected by employing girders,



as in the figure, from wall to wall, and tenoning the joists into them. This would reduce the supporting points to four in number, and would entirely obviate the necessity of wall-plates.

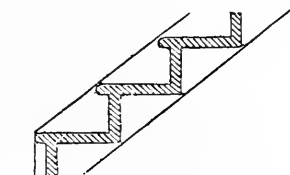


Section.

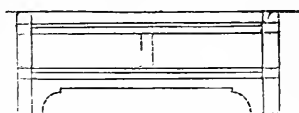
The figures also show the skirting-boards or fillets with the plastering brought down to the floor-boards, and carried through, thereby forming a perfect key, and at the same time leaving no hollow space for harboring vermin and dust.

In connection with the floors, and fire-proof construction (a most important point in cottage building,) the *Stairs* may be mentioned. As commonly constructed, the hollow space formed by the tread and riser is enclosed by a flat plaster covering or ceiling, having a most unsightly appearance, and rather aiding than preventing their destruction in case of fire.

The engraving shows the bearers of wood, but the tread and riser of earthenware, to be formed in one piece, for strength. Stairs thus formed would be fire-proof, and would have a neat appearance.



Section of stairs formed of tile.



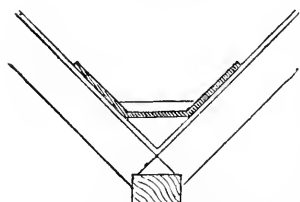
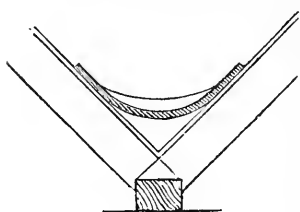
Elevation.

The *Roofs* of cottages may be formed of a great variety of materials, and a number of modes of construction have been invented.

For the humbler kind of dwellings, *thatch*, though falling into disuse, seems admirably adapted; not only as being cheap, but as being the warmest of all coverings, and less liable to admit the changes of temperature. The objection, its liability to take fire, may be, to a great extent removed

by soaking it in a mixture of alum water and size. It is usually made of combed wheat straw, called reed, consisting of the stiff, unbruised and unbroken stalks which have been carefully separated from the fodder straw by the thrasher. A more durable thatch is formed of the spray of trees, previously well-seasoned, hoop chips, and the chips of coppice wood.

The roofs may be covered with the common *pan* or *plain*

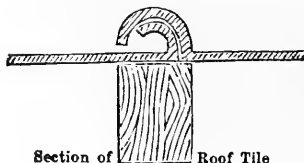


Sections of valley tile.

*tiles* in the usual manner, the ridges and valleys being also formed in tile. The ridge tiles should always form a straight line; and a great improvement in the valley tiles would be the making them in long lengths, and forming the necessary fall in the thickness of the tile itself, as in the figures; no gutter fillets would be required, and it would be perfectly weather-tight, especially if where a joint occurs it were set in cement, and the joint formed.

The *French roofing tiles*, are square in form, and about 9 inches across, with a raised ledge on two sides. They are laid with or without mortar, diagonally, so that the rain-water never hangs to the joints, by capillary attraction, but runs to the lower points, and from thence to the flat surface of the next tile. These tiles are lighter than pantiles.

A great variety of *ornamental tiles* (some of them sufficiently fanciful) have of late been manufactured. A better mode of joining them, and one requiring no mortar, is shown

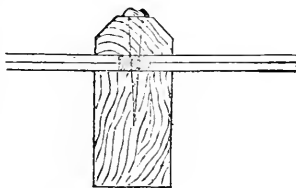


Section of Roof Tile

in the figure, as the water creeping in under the edge of the upper tile would be effectually stopped by the curved inner rim, which, by its form,

would prevent the water from making its way to the roof-timbers.

A very economical plan of covering a roof with *slate* has lately been introduced, as it only takes half the quantity of slates, requires no battens, and, if large ones are used, a less number of rafters. In this plan of covering a roof, the slates are fixed in the same manner as glass in a skylight, but instead of being inserted in a rebate, a fillet of wood is used, about  $1\frac{1}{4}$  inch high, and 1 inch broad on the top, and  $\frac{3}{4}$  inch broad at the bottom: this slip is nailed down the centre of each rafter, and the slate stopped in with putty in the manner above mentioned, each slate having a lap of from 2 to 3 inches. This mode of slating, if carefully performed and kept well painted, will last for a number of years. One objection to it is its extremely slovenly appearance, as not only the line formed by the putty cannot be kept even, but the paint is commonly found smeared half over the slate. By forming it as in the figure, this is remedied: a strong wooden fillet is nailed over both slates, thereby making a perfectly secure joint, as well as showing a neat appearance. The fillet should be well painted before fixing.



Section of slate roof.

*Cast-iron* roofing has occasionally been employed for cottages, and *corrugated iron* may be used with great advantage, as no rafters are required, and it can be used in long lengths without fear of bending.

As a slight improvement in these roofs, the method here shown might be adopted. The raised portion would not only greatly strengthen it, and allow the iron to be used in longer lengths, but it would have a better appearance.

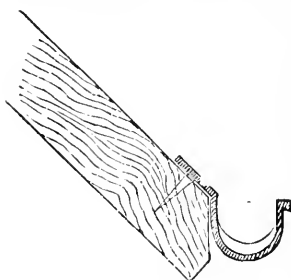


Section of corrugated iron.

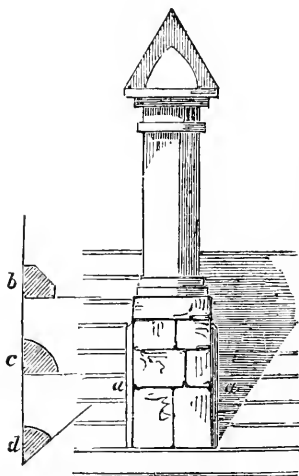
The eaves-gutters, when there are any, are commonly

formed of cast-iron or zinc,\* and have a very unsightly appearance, from the fall not allowing of their being fixed parallel to the line of eaves, besides their liability to sag between the supports

Of late, a wooden gutter has been used, with the fall formed within its own depth, thereby keeping a horizontal line. The joints should be as few as may be, and where they occur should be carefully mitred. These wooden gutters must occasionally be painted. The same form might be used in tile, as the figure, in as long lengths as possible, and with the joints formed as above described for the valley tiles.



Section of tile eaves-gutter.



Elevation of a chimney-shaft, showing tile angle fillets.

The angles formed by the chimney-shaft and the roof, as also those formed by the roof and wall, are, in the more expensive houses, covered with lead, which, besides expense, does not harmonize in color with a tile roof; and in the commoner sort, are merely jointed with mortar or cement—a very imperfect method, as the weather speedily causes it to crumble away, and it then becomes necessary to renew it, and is continually a source of trouble and expense.

By using a tile-fillet of the

\* Sometimes the ridges and gutters of a roof are formed of a substance called marine-metal; so named, apparently, from its wavy appearance and changeable properties when in such situation.

shape indicated in the figure, and set in cement, a perfectly secure and water-tight joint would be formed, having a very neat appearance. It is here represented in elevation at *a a*, and the figures *c, d, e*, show different forms of tiles.\*

#### VENTILATION AND WARMING.

As economy in materials and construction is absolutely necessary in all that relates to cottage building, any mode of *Ventilation* which could be proposed must be accomplished without any extensive apparatus, and of so simple a nature as to be nearly or quite incapable of derangement.

The prejudice in favor of an open fire being so great, it is imperative in all cases to provide for it; and as it always makes the largest demand on the air of a room, it should be separately supplied, so as to be perfectly independent of doors and windows.

The best way of doing this, at least in cottages, is to connect each fire-place with the outer air by means of a flue-tube at the level of or under the floor, opening out just above the ground surface, and admitting the air behind, or at the side of the grate. The tube may be either formed in the brickwork itself, of metal, or of earthenware. Both the external opening and the opening into the fire-place should be closed by a grating.

This mode of supplying the fire with air would (from experiments made by Mr. HOSKING) also supply the room as well with a sufficient quantity of fresh and tempered air for all purposes; the more especially as, according to Dr. ARNOTT, a sufficiency of fresh air always enters a room by the spaces left in consequence of the imperfect closing of doors and windows, and the occasional opening of the door.

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\* Tiles of this form, made circular on plan, might be used with advantage for setting the common chimney-pots, instead of the unsightly mass of mortar usually cobbled round them.

In most cases where attempts are made to ventilate rooms, the fresh air is admitted by an opening connected with the outer air, and at the level of the floor, through the skirting,—a very imperfect method, not only as being dirty, the air collecting dust as it passes, but as creating a draught along the floor in its passage to the opposite opening. By admitting air through earthenware tubes, at about seven feet above the floor, or just above a person's head, both these sources of annoyance and discomfort would be avoided; the clean earthenware tube would be free from dust, and the cold air would mix with the warm air in the room above the head, and could not therefore be felt as a draught; and as the fire is supplied separately, no down current would be likely to take place.\*

The vitiated and heated air in each room may be carried off by the chimney-flue, through an orifice just below the ceiling, fitted with one of Dr. ARNOTT's chimney-valves or some similar apparatus, or even by a simple opening.

In this chapter we have made free use of Mr. ALLEN on "Improving cottages for the laborer."

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\* In houses of two or more stories, it would be better to draw the air for the supply of the fire; and also for ventilating the rooms, from the staircase, the air in it being warmer than the external atmosphere; and it would at the same time be itself ventilated, means being of course provided in it for the admission of a sufficient quantity of fresh air.



## CHAPTER III.

## TERRA DEL FUEGO COTTAGE.

FROM COMMODORE WILKES' report of his exploring expedition, we extract the following account of the Fuegian houses: "The houses are generally built near the shore at the head of some small bay, in some secluded spot, and sheltered from the prevailing winds. They are built of boughs or small trees, stuck in the earth, and brought together at the top, where they are firmly bound by bark, sedge and twigs. Smaller branches are then interlaced, forming a tolerably compact wicker-work, and on this, grass, and turf and bark are laid, making the hut quite warm, and impervious to the wind and snow, although not quite so to the rain. The usual dimensions of the huts are seven or eight feet in diameter, and about four or five feet in height. They have an oval hole in which to creep. The fire is built in a small excavation in the middle of the hut. The floor is of clay, and has the appearance of having been wet-kneaded. The usual accompaniment of a hut is a conical pile of muscle and limpit shells opposite the door, nearly as large as the hut itself."

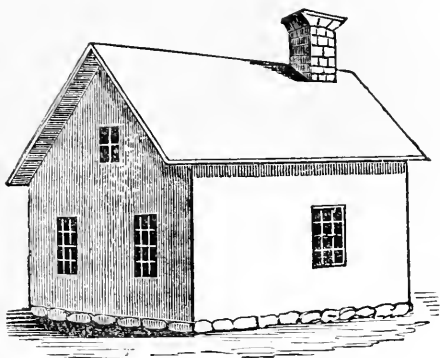
We do not presume that any of our readers will adopt

the cottage of the Fuegians. Should an American or European be just settling in a new country, where he enjoyed no greater facilities for building than does the Fuegian, he would erect a house of the same materials, as much superior in convenience and beauty to the Fuegian hut as its builder is his superior in intelligence ; instead of taking the twigs or branches of trees, he would take the trees themselves, cut them in logs of even lengths, notch them at the ends, and place them upon each other—making a log-house as shown in the engraving. The roof may be made of straw, slabs, boards, or such other material as shall be convenient. The crevices between the logs may be filled with mortar or mud. The engraving is no fancy sketch ; there are thousands of such log-cabins in our country, built by hardy hands, on soil owned by their occupants, and which possess every requisite for their owners' convenience, comfort and happiness.



Log-cabins are often made to assume the appearance of frame houses, by fastening perpendicular strips on the logs outside and nailing on clap-boards, and the inside may be plastered or lath and plastered. Such a cabin was the residence of President Harrison, at North Bend, Ohio.

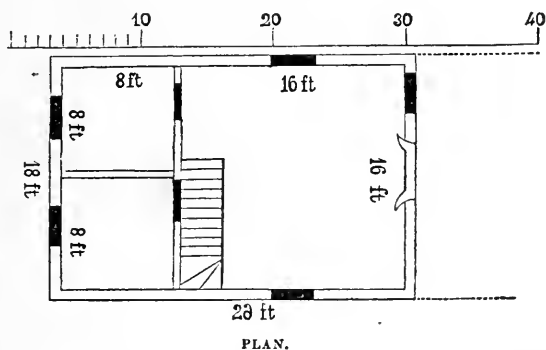




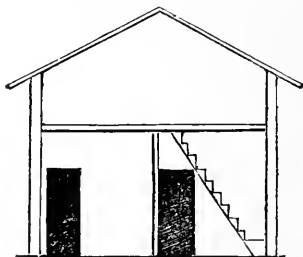
## CHAPTER IV.

## PRAIRIE COTTAGE.

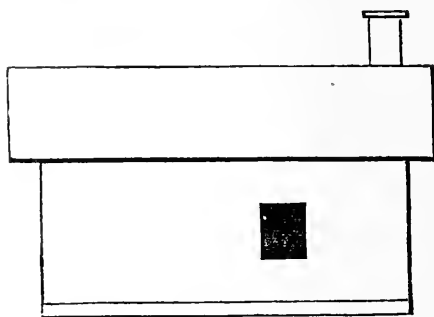
THIS DESIGN is for a cottage of unburnt brick, and is peculiarly adapted to settlers on the prairies in the Western States.



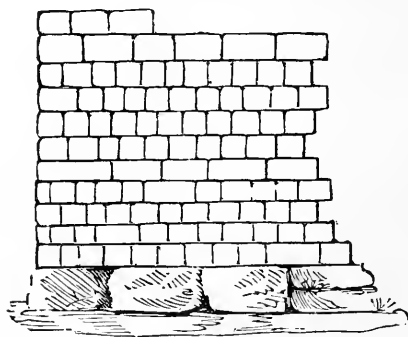
The above is the ground plan. The dotted lines show in what direction the building should be extended.



CROSS SECTION.



SIDE VIEW.



This engraving shows the manner of laying the unburnt brick and the foundation.

The house is twenty-eight feet by eighteen, forming one room sixteen feet square, and two bed-rooms eight feet square, on the first floor. The house has but one door, which is so located as to lead into the additional room, should one be built; a stairway is made into the upper story, (*see cross-section*) by extending the outer walls three or four feet above the joists, which rest on the brick. The upper room will admit of a division, making a lodging-room over the bed-room, or it may be used to accommodate boarders. The window-frames are made of plank of the thickness of the walls—the panes being eight by ten inches; cost from three to five cents per light. Five windows are needed for the whole house. Unburnt brick, although suitable for the walls, will not answer for cellar work: that must be of stone. Nearly every kind of clay is suitable.

The above is a correct description of some cottages erected by Hon H. L. ELLSWORTH, late Commissioner of Patents, and as the plan is one of interest to emigrants and settlers in the western prairie States, we copy the following from *his plan for cheap cottages*:—Select a suitable spot of ground, as near the place of building as practicable, and let a circle, ten feet or more be described; let the loam be removed and the clay dug up one foot thick; or, if clay is not found on the spot, let it be carted in to that depth. Any ordinary clay will answer. Tread this clay with cattle, and add some straw cut six or eight inches long—using two common bundles to one hundred brick. After the clay is tempered by working it, the material is duly prepared for the brick. A mould is then formed of plank, of the size of the brick desired. In England, they are usually made eighteen inches long, one foot wide, and nine inches thick. I have found the most convenient size to be one foot long, six inches wide, and six inches thick. The mould should have a bottom not air-tight, since mortar will not fall when a vacuum is produced. The clay is then spread in the moulds in the same manner that brick moulds are ordinarily

filled. A wire or piece of iron hoop will answer very well for striking off the top. One man will mould about as fast as another can carry away—two moulds being used by him. The bricks are placed upon the level ground, where they are suffered to dry for two days, turning them edgewise the second day; and then packed in a pile, protected from the rain, and left ten or twelve days to dry. During this time, the foundation of the building can be prepared. If a cellar is desired, this must be formed of stone or brick, two feet above the surface of the ground.

For cheap buildings on the prairies, where stones are scarce, wooden sills, twelve or fourteen inches wide, may be laid on piles or stone. This will form a good superstructure.

In all cases, before commencing the walls for the first story, it is very desirable, as in walls of brick, *to lay a single course of slate*. This will intercept the dampness so often arising in the walls of brick houses. The wall is laid by placing the bricks lengthwise—thus making the wall one foot thick. Ordinary clay, such as is used for clay mortar, will suffice for laying up the brick; though a weak mortar of sand and lime, where these articles are cheap, is recommended, as affording more adhesive material for the plaster. A mortar composed of three parts clay, two parts ashes, and one part sand, is very good; and this, when lime is not plenty, answers for plastering the inside. For ceiling, nowever, where there is walking over head, lime plaster should be used. The walls may safely be carried up one, two, or three stories, and the division walls may be six inches thick—just the width of the brick. The door and window-frames being inserted as the walls proceed, the building is soon raised. The roof may be shingles or thatch. In either case, *it should project over the sides of the house, and also over the ends, at least two feet, to guard the walls from vertical rains*. The exterior wall is plastered with good lime mortar, mixed with cattle's hair, or hogs' bristles, (short ones,) and then with a second coat, pebble-dashed

The inside is plastered without dashing. The floors may be laid with oak boards, slit, five or six inches wide, and laid down without jointing or planing, if they are rubbed over with a rough stone after the rooms are finished. Doors, of a cheap and neat appearance, may be made by taking two boards of the length or width of the doors—placing them vertically, they will fill the space. Put a wide batten on the bottom and a narrow one on the top, with strips on the sides and a strip in the middle.

This door will be a batten door, presenting two long panels on one side and a smooth surface on the other. If a porch or veranda is wanted, it may be made with cedar posts placed in the ground, with shingle or thatched roof. Houses built in this way are dry and warm in winter, and cool in summer, and furnish no retreat for vermin.

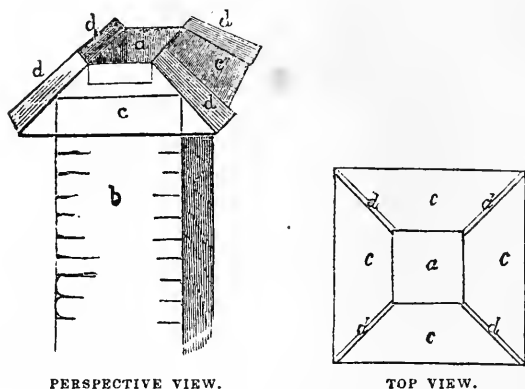
They can be made by common laborers in a very short time, (a little carpenter's work excepted,) and with a small outlay for materials, exclusive.

These walls have stood well in Canada, Europe, and South America, effectually resisting the action of the frost and rain. Unburnt brick being less porous than burnt brick, do not absorb moisture, and are consequently less damp.

On the western prairies, where clay is usually found about fifteen inches below the surface, and where stone and lime are often both very cheap, these houses might easily be built. The article of brick for chimneys is found to be quite an item of expense in wood houses. In these mud houses no bricks are needed, except for the top of the chimneys, the oven, and castings for the fire-place; though this last might well be dispensed with; and a cement to put around the chimneys, or to fill any other cracks, is easily made, as before mentioned, by a mixture of one part of sand, two of ashes, and three of clay. This soon hardens, and will resist the weather. Boiled linseed oil may be added, to make the composition.

For receipts for washing buildings, see the Chapter on Paints.

The following plan of a chimney-cap for insuring a draught and preventing the wind from blowing down the stack, is worth attention. It is represented by these two drawings:

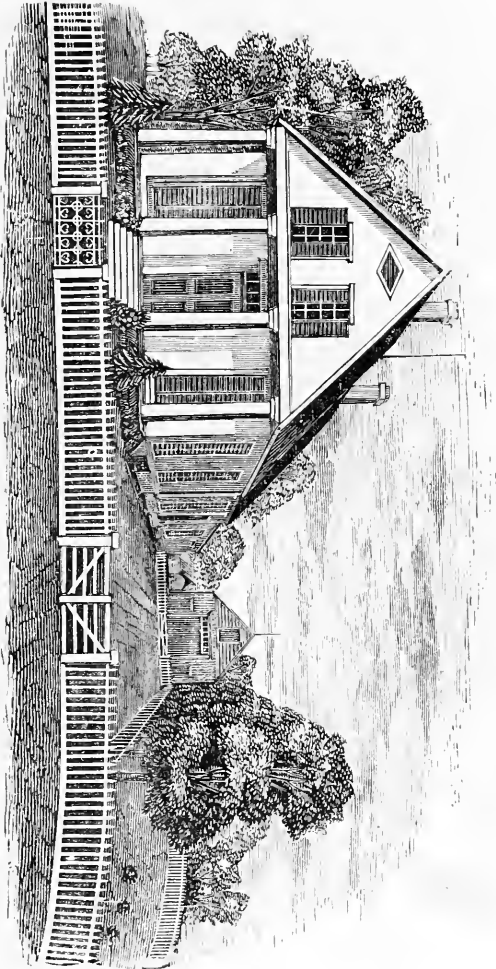


PERSPECTIVE VIEW.

TOP VIEW.

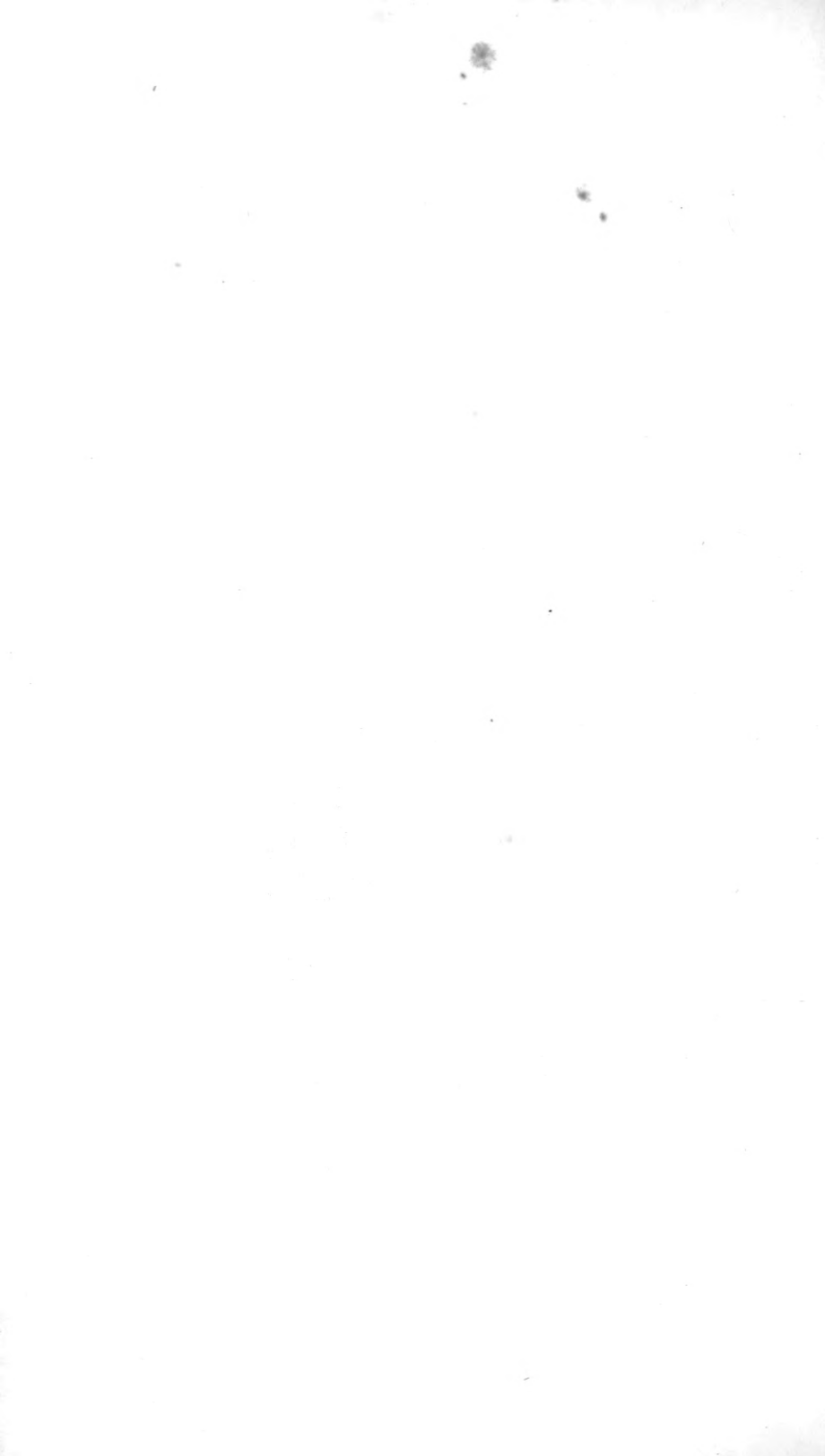
The perspective view shows a part of the stack with the cap on. The top view consists of four planes, *c, c, c, c*, placed at the top of the stack *b*, and on each side of the flue *a*, and inclining downwards therefrom, at an angle of about 45 degrees; the junctions of the planes *c*, being provided with wings *d, d, d, d*.

A current of wind impinging on one or two of the planes *c*, is deflected in an upward direction by the inclination of the plane or planes, and its velocity gradually increased in passing from the base to the top of the plane, by means of the wings, which narrow the space through which the current has to pass. This gives great force to the current in passing over the top of the flue in an upward direction, and carries with it downward currents, which otherwise might blow down the stack.



THE FARM COTTAGE.

[See p. 43]





## CHAPTER V.

## THE FARM COTTAGE.

THE MAIN BODY of this cottage is in the form of a parallelogram, 34 feet long, including the portico, and 32 feet wide, having 14-foot posts, 2 feet of which extends above the attic floor, sustaining a roof of a 16-foot pitch with the gable end facing the south or south-west. The back part of the house, which extends to the kitchen, is 18 by 23 feet, including the veranda, with 10-foot posts, supporting a roof of a 11½-foot pitch, with the gable towards the north or north-east. The kitchen is 12 by 23 feet, including the passage to the vault, with 6-foot posts, and a lean-to roof, having a 4-foot pitch.

The whole building is designed to be elevated on a terrace of mason work, 3 feet above the common level of the ground, to be built of wood, with the outer walls to be lined with bricks.

The roofs, also, are designed to be built of wood, covered either with common shingles, or water-proof cement.

On the centre of the main body of the house, a false chimney-top is shown, which may be formed of metal, bricks or artificial stone, for receiving the stove pipes from the rooms below. Those who prefer fire-places to furnaces or stoves, can erect a chimney at each side of the cottage, extending their tops about 16 feet above the eaves. Between the dining-room and kitchen, there is a chimney designed to communicate with the cooking range and stoves in those parts of the house.

This house is designed to be entered from the front gate through a portico, 6 feet wide, extending across the whole width of the house. The entry of the kitchen and dining-

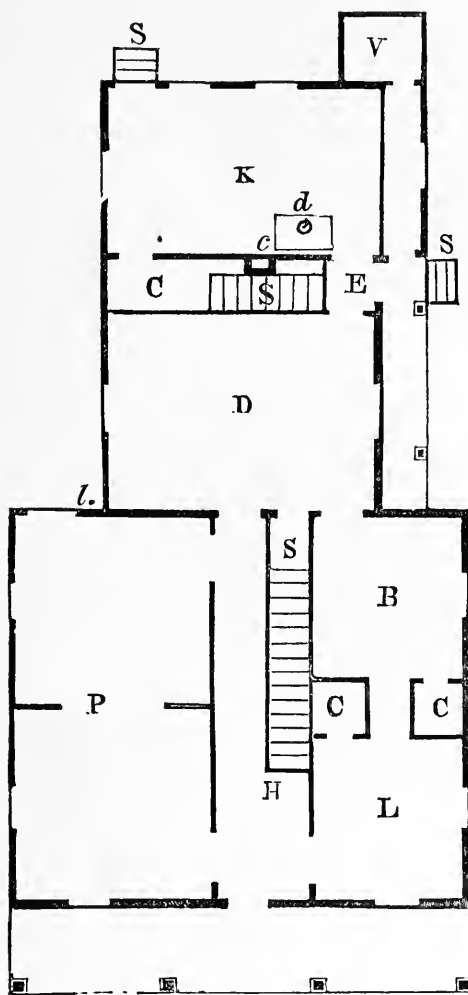
room, is also designed to be passed into on the easterly side of the back part of the building, through a veranda 3 feet wide.

The windows are all designed to be of good dimensions, and protected by wooden blinds. Towards the top of each gable end, there is a latticed window for ventilation, which may be closed at pleasure in stormy weather.

Under the entire floor of the main body of the house, a cellar is intended, with walls and arches laid in cement, to be entered by stairs from the dining-room, and by a 6-foot door-way, on the easterly side, from without.

Beneath the kitchen there is also another cellar, designed for storing wood or coal, entered from the kitchen through a trap-door, and likewise by a passage, on the easterly side, from out-doors. If circumstances require it, a dairy or milk-cellar, may also be constructed under the dining-room, and lighted or ventilated by windows at each side of the house.

The whole building is designed to be protected from lightning by a half-inch copper rod, 48 feet long, erected at the gable end, near the back parlor window, and secured in its place by means of wooden props, extending from the roofs.



*H*, denotes the front hall or lobby, 7 feet wide, including the front stairs.

*P*, a double parlor, 14 by 28 feet, with folding doors communicating with the front lobby or hall. Either or both of these parlors might be used as sleeping apartments, should circumstances require.

*L*, a room, communicating with the front hall, 11 by 12 feet, with a closet 4 feet square, and may be used for a library, office, living room or nursery, according to the tastes or wants of the occupant.

*B*, is a bed-room, designed for the head of the family, 11 by 12 feet, with a closet 4 feet square, and communicating with the library and dining-room.

*D*, the dining-room, 14 by 28 feet, communicating with the front lobby, *H*, the back entry *E*, and the cellar at *S*.

*K*, the kitchen, 12 by 20 feet, communicating with the dining-room, by the back entry *E*, and a sliding window in the pantry *C*, with the wood cellar at *D*, and the back yard by the steps *S*.

*E*, the back entry 4 by 4 feet, communicating with the veranda, kitchen, the dining-room and the back garret stairs.

*V*, the vault 5 by 6 feet, communicating with the veranda, by a passage under cover, 3 feet wide.

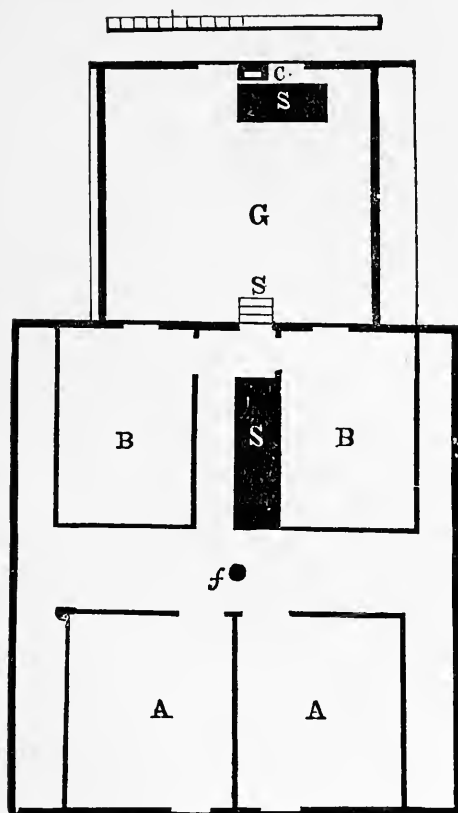
*C*, *C*, *C*, closets or pantries.

*S*, *S*, *S*, *S*, stairways or steps.

*C*, kitchen and dining-room chimney.

*d*, trap-door covered, over the wood cellar stairs.

*l*, the lightning conductor.



ATTIC FLOOR.

*A, A*, denote two front bed-rooms, 12 by 14 feet, entered independent of one another, from a lobby 6 feet wide.

*B, B*, two back bed-rooms, 10 by 14 feet; entered, also, independently of each other, from the lobby at the head of the front stairs.

*G*, a back garret, communicating with the front part of the attic, at the steps *S*, and serves as a passage-way to the kitchen and veranda by the back stairs.

*S, S, S*, denote stair-ways or steps.

*C*, the chimney of the dining-room and kitchen.

*f*, the stove funnel, communicating with the rooms below.

Between the wall-plates and bed-rooms, spaces are left 3 or 4 feet wide, which may be found convenient for storage.

The design is by D. J. BROWNE, Esq. It is designed not for a city or village, where the buildings are prescribed in their limits. The architectural style, in order to break the monotony often observable in our larger towns, should be displayed in single and double cottages, neat and appropriate out-buildings, factories, and other public buildings.

There are a variety of considerations with respect to Farm Cottages. In selecting the locations, care should be taken to get a good foundation. Stone or gravel is preferable.

The house should be near the barn and out-buildings, for reasons of convenience and security.

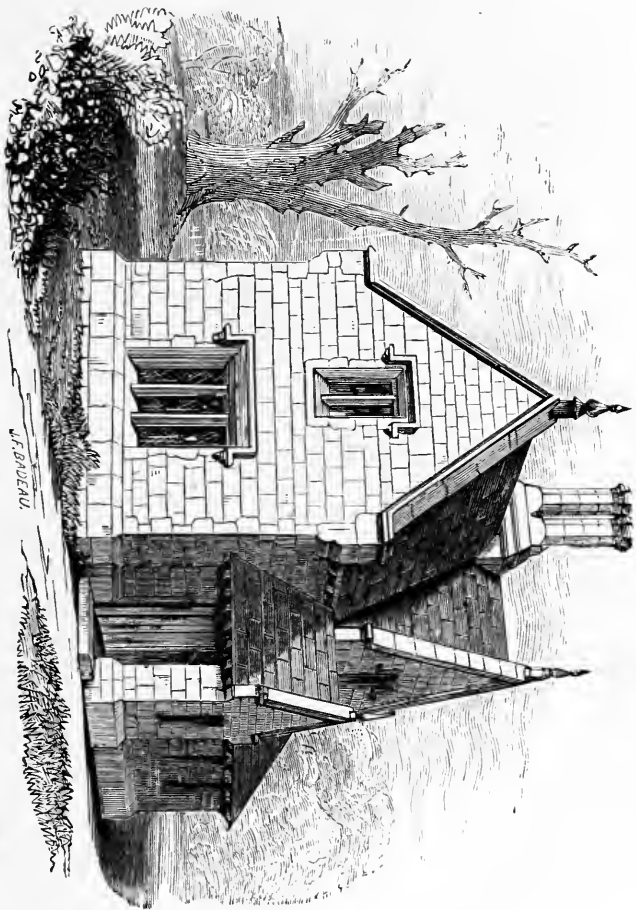
The drainage of the buildings is an important item. The drain should decline at least two feet in every one hundred.

Water may be taken from wells, or collected from the roof. A roof containing 100 square feet, will ordinarily catch 4,000 gallons of water per year.

It is generally considered the best to have cottages front the south, the west, or the south-west, especially in cold climates.

In cold climates, prominence should be given to the chimney, top, both as to its size and its mode of construction. It is suggestive of comfort, sociality, and good cheer.

At the tropics, instead of the chimney, we need the veranda—the shade. The Architect furnishes both: but change their locations, and each would be considered improper.



THE VILLAGE COTTAGE.

[See page 49.]





## CHAPTER VI.

## THE VILLAGE COTTAGE.

THIS DESIGN, BY JACKSON, represents a style of cottages much recommended and adopted in England. It should be built of stone, the walls about eighteen inches thick, and is suitable for mechanics. It consists of a living-room, fifteen feet by thirteen feet, having a south and western aspect. This room is entered by a porch on the east side. Behind the room is the kitchen, nineteen feet by thirteen feet, part of the space being appropriated to the stair-case, affording access to the bed-rooms, and the under side of the stair-case, leaving space for a small pantry. A lean-to building against the kitchen, is divided into a wash-house or scullery, and fitted up with the usual conveniences, and a tool-house and the requisite out-offices. The scullery door opens into a back yard.

The thickness of the stone walling should be from one to two feet, and the masonry, simple in its kind, receives its character from the coped gables and chamfered mullions of the windows and jambs of external doors. The ancient chimney-shaft has a base formed into two water-tables, above which rises the octangular shaft, springing from a square pedestal, and terminated by a single moulded and embattled cornice, with a neck-mould twelve inches in diameter, and the chimney seven feet high from the water-table.

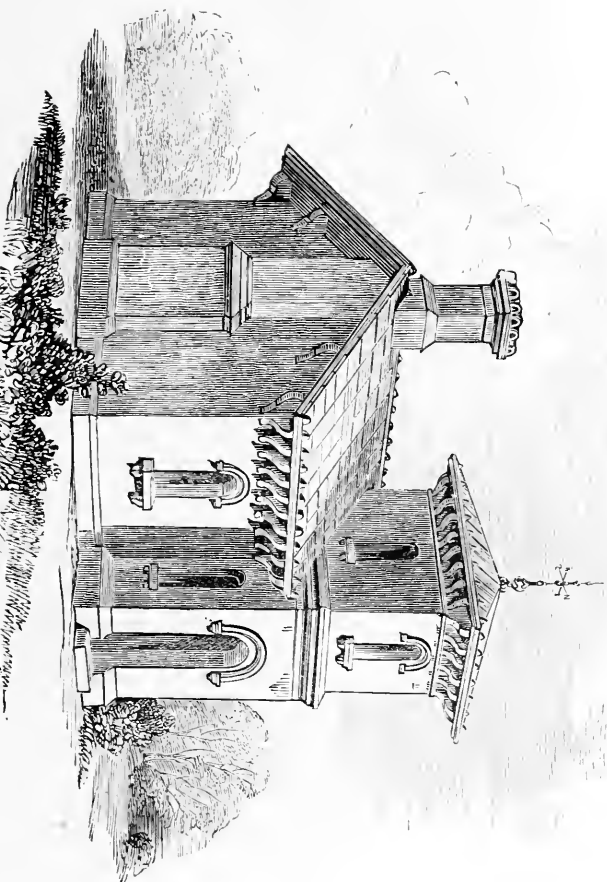
The various parts of this cottage are fully described in Chapter II.

## CHAPTER VII.

## ITALIAN COTTAGE.

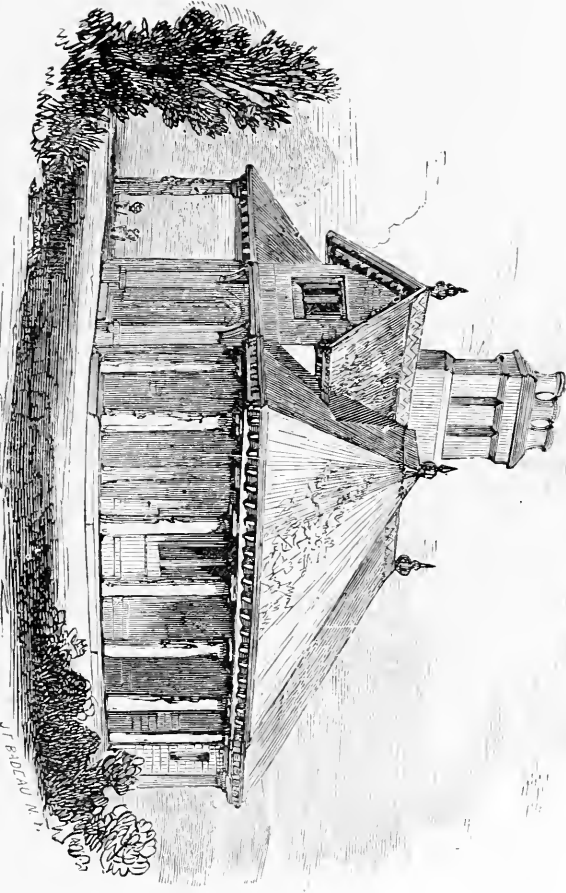
THIS DESIGN is for a position visible from a considerable distance, and commanding from its site an extensive view. The Italian style being selected, it is desirable to make the tower useful, as well as an ornamental appendage, and therefore the ground plan of the tower is used as a porch, and its second story as a bed-room. A door on the side, opens in the living-room. The tower is eight feet and a half high. The door is thus placed to avoid a direct draught into the room, and the square space between it and the back wall of the porch, would be occupied by a bench, affording a pleasant seat for the family of the occupant, during fine weather. JACKSON proposes that the living-room be fourteen by twelve feet, having on one side a narrow stair-case, affording access to the bed-rooms. Connected with this room, is the kitchen or wash-house, twelve feet square, fitted up with a cottage range, oven, sink and pump. Attached as a lean-to, is the pantry, with the usual outer-offices.

Vines should be cultivated and allowed to run up and around the tower. The drainage would be taken from the kitchen out-door way, to the nearest point at which it could be emptied with a good fall. A house in this style, built cheaply of wood, should not cost over \$450, while, if made of stone in a substantial manner, it would cost \$900. The cottage is especially adapted for a lodge, in which case the tower might be used as an observatory, or it may be occupied by a small family, when the tower would be used as a bed-room. The rural beauty of the house would be greatly increased by the arrangement of the trees, foliage, and grounds about it.



ITALIAN COTTAGE. [See p. 50.]

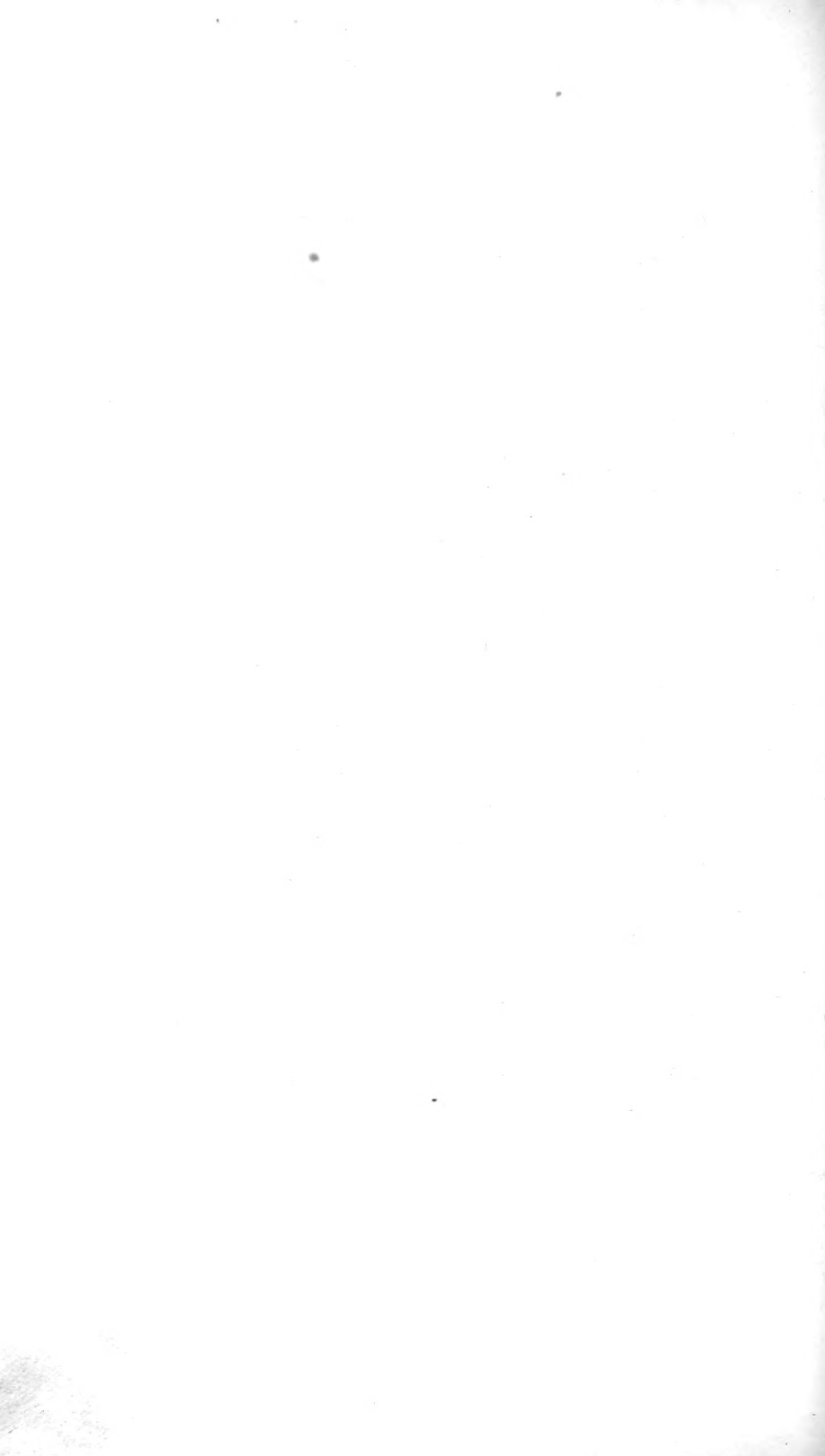




THATCHED COTTAGE.

See p. 51

J. F. B. D. C. A. N. P.



## CHAPTER VIII.

## THATCHED COTTAGE.

IN MANY situations, Thatched Cottages form a distinguishing feature in the landscape; and, says JACKSON, combine essentially with the scenery of the country. This style is well worthy of occasional use, and very suitable for lodges. Straw thatching is a covering easily provided in any agricultural vicinity, and is capable of being repaired from time to time, at a trifling cost: but it is easily accessible to vermin, and, therefore objectionable, for the better class of cottages. Reed, being more impervious to their attacks, is the material to be recommended—with its closeness of texture and harmony of view, aided by the neatness of effect which can be given to it by experienced thatchers. Creeping-plants spreading over the surface of the roof, greatly contribute to the general effect; and a cottage in this style, derives great assistance, in its picturesque character, from the judicious aid of the landscape gardener.

Thatched Cottages are less frequent in this country than in Europe, in consequence of the cheapness of better material, and the ability of the cottager to get it.

Mr. JACKSON designed the "Thatched Cottage" for England. Although we feel bound to give a specimen of a Thatched Cottage, in fulfilment of our design, still, we must record our pride that our people generally, can afford better houses.

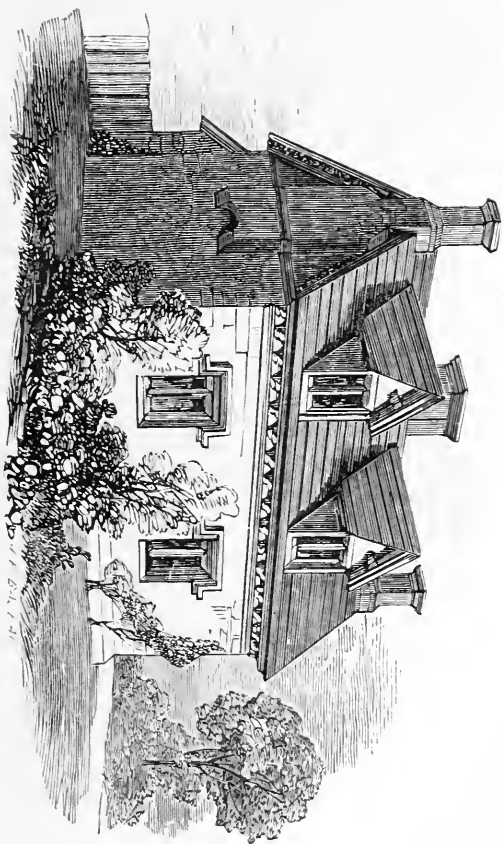
The design does not aspire to a high degree of Architectural beauty.

The design is an adaptation of this material to a lodge, and the roof is extended sufficiently to answer the purposes

of a veranda, on the south, or principal front of the dwelling. The entrance, on the west side, is a porch, seven feet by five feet, opening into a living-room, fifteen feet by thirteen feet, exclusive of a bay window, and having on its east side a kitchen, thirteen by eleven feet, fitted with oven and sink. Two bed-rooms are obtained over the kitchen and living-room. Attached to the kitchen, is a wing building comprising tool-house and the usual out-buildings. The veranda gives access, under cover, to these buildings, in addition to its importance as an ornamental feature. In selecting the uprights to support this veranda, much care should be exercised, and a degree of artistical judgment employed. They should be neither too regular in form, nor on the contrary, too distorted. If any arms, or branches, are retained at the upper extremity, to give the semblance of an arch, the same observations will apply; but a practiced artist's eye can only succeed in this point. Oak unbarked posts, having lead at the head and foot, should be the material selected. Considerable drip will fall from the eaves, and the building must be surrounded with a channel **drain**, under this drip.

The cost will vary from \$400 to \$900.





COTTAGE OF THE SOCIETY FOR IMPROVING THE CONDITION OF THE POOR.—[See p. 63.]



## CHAPTER IX.

COTTAGE OF THE SOCIETY FOR IMPROVING THE  
CONDITION OF THE POOR.

THIS DESIGN provides a living-room fourteen-six by fifteen feet, and eight feet high, with a window on the south side, a chimney on the east, and the door into the room at the north-west angle—thus affording the utmost possible space for the little furniture which the tenant may have to arrange in his “best room.” A lobby three and a half feet square protects the entrance to this room from the draughts of the external air, and this lobby forms the outer entrance, giving also access to the pantry, three and a half feet wide, running north-ward ; and a scullery, eight feet square, fitted up with sink, pump, copper, and if requisite, an oven of small dimensions. The first step of the stairs commences at the northern jamb of the living-room chimney, and under the stairs adjacent, the entrance is obtained to a coal or wood closet. The scullery is made one foot lower than the living-room, and by this means access is obtained off the stairs to a room over, thus providing three bed-rooms, each with a chimney.

All the rain water is collected from the roofs into a water butt placed at the northern extremity of each pantry. A small yard is formed on this side, in which a well is sunk for the use of the pair of cottages, and at the extremity of this yard the dust-holes, &c., are placed, thus keeping the house clear from all contamination on the score of drainage. The garden is to occupy the south front of the cottage, and the aid or the cottager would of course be expected in training honeysuckle or whatever he most desired along its frontage. The cost of the pair would vary from \$800 to \$1,000.

## CHAPTER X.

## WARMING AND VENTILATION.

THE atmosphere is composed essentially of two gases, in a state of mechanical mixture, named oxygen and nitrogen. In its pure state, oxygen is chiefly remarkable for its energetic properties in promoting combustion, decomposition, and various chemical changes. A taper, with a mere spark of fire in the wick, will, when plunged into oxygen, burst into flame and burn brilliantly; iron wire, made red-hot at one extremity, will burn away with the greatest ease in this gas. An animal in an atmosphere of pure oxygen, suffers from excess of vital action; its pulses throb with increased rapidity and vigor, the vital spark, as it were, bursts into flame, and destroys the animal. Nitrogen (or, as it is sometimes called, *azote*,) is as inert in its properties as oxygen is active. It supports neither life nor combustion, and its principal use in the atmosphere seems to be to dilute the oxygen, and to subdue the wonderful energy of this vigorous element to the endless number of useful purposes which it has to perform in the economy of nature. The proportions in which these two gaseous bodies are mingled, are very unequal; every atom or particle of oxygen in the atmosphere is accompanied by four atoms or particles of nitrogen; or, in other words, if we take a measure of any capacity, divided into five equal parts, and decaut it into four parts of nitrogen and one part of oxygen, we get a mixture identical in all respects with pure atmospheric air.

In the great chemical operations of nature, which are dependent on the atmosphere, oxygen passes through various mutations, and enters into new combinations, which form

the bases of grand and wonderful contrivances. Some of the most important of these operations depend on the process of combustion, of which the following is a simple illustration: A piece of wax taper, fixed in the centre of a cork, is lighted and floated on the surface of water in a shallow dish; if this be enclosed within a glass bell, the mouth of which dips into the water and rests on the dish, the air of the glass will be cut off from any communication with the external atmosphere. The flame of the vapor will immediately diminish, and in a few seconds be extinguished. On examining the air left in the glass, it will be found incapable of supporting animal life or combustion; four-fifths of the original bulk of air is still nitrogen, and this is apparently unchanged; the remaining fifth is no longer oxygen, but a compound of oxygen with the carbon and hydrogen of the flame—oxygen and carbon producing carbonic acid, and oxygen and hydrogen producing water, which, in the form of vapor, condenses on the inner surface of the glass.

Now, the product of combustion called carbonic acid, is incapable of supporting life and combustion, and thus resembles nitrogen. But there are these differences between them; nitrogen is a little lighter than its own bulk of atmospheric air—carbonic acid is considerably heavier; nitrogen is an elementary or simple substance, that is, one which has never yet been resolved into two or more dissimilar parts—carbonic acid, on the contrary, is a compound capable of being separated or decomposed into carbon or charcoal and oxygen. Moreover, pure nitrogen, shaken up in a bottle, with a little lime water, produces no effect; carbonic acid renders it turbid, by combining with the lime and rendering it insoluble; nitrogen is scarcely absorbed by water, but water absorbs its own volume of carbonic acid; nitrogen has no taste or smell—carbonic acid has a sharp taste and an acid reaction. Hence it will be seen, that these two bodies, which have the common property of ex

tinguishing life and preventing combustion, are marked by characteristic differences.

Some idea may be formed of the enormous demands on the oxygen of the atmosphere, for supporting combustion, from the fact, that a single iron furnace burns or consumes, in the course of twenty-four hours, not less than three hundred and ten tons weight of atmospheric air, or as much as would be required for the respiration of two hundred thousand human beings within the same period.

Carbon, which forms the solid basis of most fuel, and in a minutely-divided state renders flame luminous, is a simple substance, and exists in nature under a variety of forms. Its purest form is the diamond, as is proved by the formation of carbonic acid only, when it is burnt in pure oxygen. Charcoal and Coke are other well-known forms of carbon, the one obtained from wood, the other from coal; coal is a compound of carbon, hydrogen, nitrogen and oxygen, with a mineral and earthy residue. Wax, tallow, &c., are compounds of carbon, hydrogen and oxygen.

Hydrogen, which is the source of all common flame, is the lightest substance that has ever been weighed: it is more than fourteen times lighter than its own bulk of atmospheric, at the same temperature; it neither supports life nor combustion. A lighted taper, plunged into it, is extinguished, but the hydrogen itself takes fire and burns at the mouth of the jar, where it is in contact with the oxygen of the air, with which it unites and forms water. One volume of oxygen combines with two of hydrogen to form water: or by weight, one grain of hydrogen unites with eight grains of oxygen; and as the hydrogen is sixteen times lighter than its own bulk, of oxygen, it follows that one grain of hydrogen will occupy twice the bulk of eight grains of oxygen. Pure hydrogen burns with scarcely any light; in the flame of our lamps, candles, gas-lights, &c., the minutely-divided carbon, in rising up through the flame, becomes white-hot, and presents innumerable luminous points; at the exterior

of the flame the oxygen of the atmosphere seizes the minute atoms of carbon as they escape, and by combining with them, forms invisible carbonic acid. A cold substance, such as a piece of glass or metal, held in a flame for a moment, will condense a portion of the carbon in a minutely-divided state. If a lamp have a deficient supply, it will smoke, that is, a portion of the carbon of the flame will escape without being burned. Lamp-black is formed by burning oil in a close chamber with a deficient supply of air.

Hydrogen unites with nitrogen to form ammonia, three volumes of hydrogen being required to one of nitrogen. This substance is pungent and acrid, but when diluted with air, is an agreeable stimulant. It is very soluble in water, which, at the temperature  $50^{\circ}$ , takes up 670 times its bulk of the gas. Ammonia is an alkali, and combines readily with acids, producing an important class of ammoniacal salts.

Nitrogen and oxygen combine to form nitric acid, one part of nitrogen uniting with five parts of oxygen. Not only are these numbers different from those which represent the composition of the atmosphere, but the mode of combination is different. The oxygen and nitrogen of the atmosphere are mixed mechanically, just as a portion of fine sand diffused through water, may be said to mix with it without combining. In either case, the bodies preserve their own peculiar properties; or the properties of the compound form a mean between those of its component elements. But in a chemical combination between two bodies, a third body is formed, whose properties need not, and seldom do resemble those of the component elements. Thus sulphur and oxygen combine chemically to produce sulphurous or sulphuric acid—substances whose properties are quite different from those of the sulphur and oxygen which produce them; the sulphurous has also very different properties from the sulphuric. So with nitric acid; this compound has none of the properties of the constituents of the atmosphere, but a new set

of properties peculiar to itself. This powerful acid may be formed artificially in various ways, but only one need here be mentioned. By passing a succession of electric sparks through a mixture of oxygen and nitrogen, this acid is formed; so also during a thunder storm, the lightning striking through vast masses of atmospheric air, produces nitric acid, which, combining with ammoniac, also formed in the atmosphere, descends with the rain upon the earth in the form of nitrate of ammonia.

Now, the object for which these details have been brought forward, is to enable the reader to take an enlarged view of the process of combustion, for this, in fact, constitutes the chief means by which which nature accomplishes her annual cycle. An accurate knowledge of the homely processes of warming and ventilation depends upon a clear insight into the principles of combustion, and it is only an oft-repeated truism, that our useful arts become more efficient in practice, more economical and more conducive to our happiness, in proportion to our knowledge of the principles upon which they depend. Now, according to the common acceptance of the term, combustion is the rapid union of a combustible with a supporter of combustion whereby new compounds are formed, heat and light accompanying the formation. Thus, a piece of iron wire or of phosphorus ignited and plunged into a jar of oxygen gas, burns vividly, the iron falling in molten drops amid showers of scintillations, and the phosphorus emitting a vivid flood of painful light. By this process, the oxygen and the iron unite to form a new substance—oxide of iron; the oxygen and the phosphorus also form a new substance, phosphorous acid. If, however, the iron be exposed long enough to the atmosphere, the oxygen will combine with it in precisely the same manner, and form oxide of iron. Months or even years may be required for the completion of the process which in the jar of oxygen was accomplished in a few seconds; but the result is the same. The same amount of heat is evolved by



the combination of the oxygen and the iron during the slow process of rusting, as in the rapid process of burning. So also with the phosphorus. A piece of this substance exposed to the air combines with the same amount of oxygen, and evolves precisely as much heat during the time that it slowly wastes away, and produces the same weight of acid as it would do if burnt in a jar of oxygen.

Now, it must be evident, that if a process, rapidly brought about in one case and slowly in another, produce the same results, we do not add to our knowledge by associating different names and different trains of thought with the one as compared with the other; on the contrary, we disembarass the subject by considering the processes as identical; whether the combustion be rapid or slow, it is still combustion. Undoubtedly there are cases where slow combustion is not possible. A piece of coal and the oxygen necessary to its combustion may remain in contact for centuries without undergoing any change; but the moment a spark of fire is introduced, they begin to combine and disappear, with all the more obvious phenomena of combustion. In such a case, all we can say is, that a high temperature is necessary for the combination; but this case does not disturb the view we are endeavoring to impress upon the reader, that combustion may be a very slow process as well as a very rapid one.

Let us take another case of combustion. If a portion of the solid food of animals be placed in a red-hot platinum crucible, it will burn away; its carbon will unite with oxygen from the air, and form carbonic acid; its hydrogen will unite with oxygen from the air and form water; its nitrogen may escape free, or it may unite with a portion of its hydrogen, and form ammonia; and in this way all the gaseous volatile products will be expelled from the crucible, leaving behind only a small portion of ash, which consists of salts, some of which are soluble in water, and others insoluble in that fluid.

Now, in a chemical point of view, the living animal frame is a real apparatus for combustion ; it is a vital furnace, in which the carbon supplied by the fuel which we call fuel, is burnt, and, combining with oxygen, escapes by the lungs and the skin into the atmosphere, under the form of carbonic acid. In this apparatus, also, the hydrogen of food is burnt, and uniting with oxygen, escapes as aqueous vapor ; the nitrogen of the air, as taken into the lungs, is again exhaled by respiration, but the nitrogen and soluble mineral portions of the food are rejected in an insoluble or soluble form.

Every portion of food which a person of mature age takes into his system, is thus dispersed from day to day. In infancy and youth, a portion is retained to form materials for growth ; in old age, the individual loses more than he receives, and consequently, wastes slowly away. But in each case, the natural process is similar to the artificial one represented in the heated platinum crucible. We cannot, therefore, resist the evidence that the combustion of food, whether in the animal or in the crucible, is one and the same process ; the only difference being, that in the crucible the heat is intense and the process comparatively slow. That which is called animal heat ( $98^{\circ}$  Fah.) is in fact the heat of combustion, and the object of the domestic process of warming and ventilation is to enable the animal to maintain this heat, and to convey away the gaseous products of combustion as fast as they are formed. The soluble and insoluble products of combustion are conveyed away by other natural means ; and it will be our duty, hereafter, to show that it is as unwise to neglect the means for clearing off our gaseous excrements, as it would be insane and unnatural to attempt to retain those of another kind.

Another proof of the identity of the two processes is that nature disposes of the products of combustion in precisely the same manner, whether derived from ordinary combustion or animal respiration. The vegetable kingdom

is the grand laboratory wherein these products of combustion are decomposed and elaborated into new combustion. Plants inhale or absorb carbonic acid, decompose it, retain the carbon as materials for growth, and return the oxygen back to the atmosphere; plants absorb water or aqueous vapor, decompose it, retain its hydrogen, and also return the oxygen back to the atmosphere; plants sometimes take nitrogen directly from the air, and also sometimes indirectly from the oxide of ammonium or from nitric acid. Thus it will be seen that the chemical function of plants is directly the reverse of that of animals—the animal kingdom constituting an immense apparatus for combustion—the vegetable kingdom an equally grand apparatus for reduction; in which reduced carbonic acid yields carbon, reduced water its hydrogen, and in which also reduced oxide of ammonium and nitric acid yield their ammonium or their nitrogen. The organic matter which constitute the food of animals is destroyed by them, and rendered for the most part inorganic: this, in its turn, becomes the aliment of plants, the materials with which plants elaborate organic compounds, the atmosphere serving as the means of communication between the two kingdoms. Organic vegetable substances pass, ready-formed, into herbivorous animals, which destroy a portion of them, and appropriate the remainder as materials for growth. From herbivorous animals, these organic matters pass, ready-formed, into the carnivorous, who destroy or retain some of them, according to their wants. The herbivorous animals are slaughtered for the use of the carnivorous, and when these, in their turn, cease to live, they decompose, and the atmosphere again takes up, in various ways, and by various processes, the materials of which they are composed.

The great stimulus which gives motion to the wonderful machinery of the vegetable world, is solar light. Under its influence, the carbonic acid yields its carbon, the water its hydrogen, the ammonia its nitrogen. It is not for the pur-

pose of purifying the air that plants are especially necessary to animals. Their great use is to furnish a never-failing supply of organic matter, ready-prepared for assimilation; in short, with fuel, which animals can burn for their own use. The purification of the air by vegetation is a remote service; the other service is so immediate, that if it were to fail us during a single year, the earth would be depopulated. The mean amount of carbonic acid in the atmosphere, is scarcely one volume in 2,000, which is a surprisingly small quantity, when we consider how numerous and productive are the sources of this gas. Volcanoes, fires, animals, fermentation and decay, are constantly producing it. Nor will the quantity given off by a single individual appear insignificant, when it is stated that Sir HUMPHREY DAVY found that he required for the purposes of respiration, during the 24 hours, 45,504 cubic inches of oxygen, weighing 15,751 grains; and producing 31,680 cubic inches of carbonic acid, weighing 17,811, grains or 4,853 grains of carbon. These numbers vary with different individuals, and also in the same individual at different periods of the day. According to Dr. PROUT, the maximum quantity of carbonic acid is given off about noon, up to which period it gradually increases from the beginning of twilight; and after noon, it as gradually diminishes until evening, and is at its minimum during the night.

It appears, from the mean of a large number of observations, that the average quantity of carbon evolved from the lungs amounts to 130 grains per hour, or 3,120 grains in 24 hours, which is rather more than 7 ounces daily. This calculation does not take into account the carbonic acid evolved by cutaneous respiration. The quantity of oxygen consumed in respiration varies also with the state of exertion or repose of the individual. According to an observation of LAVOISIER, the consumption of oxygen in the two states was as 32 to 14. The quantity of vapor given off by the lungs has also been variously stated, but the average is

supposed to be about three grains per minute. According to THENARD, the amount of vapor given off by the skin varies from 9 to 26 grains per minute.

In the process of respiration, a full grown man draws into his chest about 20 cubic inches of air; only one-fifth of this is oxygen, and nearly one-half of this oxygen is converted into carbonic acid. Now, allowing fifteen inspirations per minute for a man, he will vitiate about 300 cubic inches, or nearly one-sixth of a cubic foot of atmospheric air; and this, by mingling as it escapes with several times as much, renders at least two cubic feet of air unfit for respiration. Now, the removal of this impure air, and the bringing in of a constant fresh supply, have been provided for by nature in the most perfect manner, and it is by our ill-contrived artificial arrangements that the provision is defeated. The expired and vitiated air, as it leaves the chest, is heated to very near the temperature of the body, viz.  $98^{\circ}$ , and being expanded by the heat, is specifically lighter than the surrounding air at any ordinary temperature; it therefore ascends and escapes to a higher level, by the colder air pushing it up, as it does a balloon. The place of this heated air is constantly supplied by the colder and denser air closing in on all sides. In the open air, the process is perfect, because there is nothing to prevent the escape of the vitiated air; but in a close apartment, the hot air, rising up to the ceiling, is prevented from escaping; and gradually accumulating and becoming cooler, it descends and mingles with the fresh air, which occupies the lower level. We thus have to inhale an atmosphere which every moment becomes more and more impure and unfit for respiration; and the impurities become increased much more rapidly by night, when lamps, or candles or gas are burning, for flame is a rapid consumer of oxygen. Under these circumstances, our only chance of escape from suffocation is in the defective workmanship of the house carpenter; the crevices in the window-frames and doors allow the foul air a partial exit, as may be

proved by holding the flame of a candle near the top of a closed door, in a hot room; it will be seen that the flame is powerfully drawn towards the door in the direction of the outgoing current; and on holding the flame near the bottom of the door, it will be blown away from the door, showing the direction of the entering current. If we stop up these crevices, by putting list round the windows and doors, so as to make them fit accurately, we only increase the evil. The first effect is, that the fire will not *draw* for want of sufficient draught; if the inmates can put up with a dull fire and a smoky atmosphere, they soon become restless and uncomfortable; young people get fretful and peevish—their elders irritable; respiration becomes *impeded*—a tight band appears to be drawn round the forehead, which some invisible hand seems to be drawing tighter and tighter every moment; the eyeballs ache and throb; a sense of languor succeeds to fits of restless impatience—yawning becomes general—for yawning is nothing more than an effort of nature to get more air into the lungs. Under these circumstances, the announcement of tea is a welcome sound; the opening and shutting of the door necessary to its preparation give a vent to the foul air; the stimulus of the meal mitigates the suffering for a time, but before the hour of rest, the same causes of discomfort have been again in active operation, and the family party retires for the night indisposed and out of humor.

But in the bed-room, the inmates are not free from the malignant influence. The closed doors, the curtained bed, and the well-closed windows, are sentinels which jealously guard against the approach of fresh air. The unconscious sleepers, at each respiration, vitiate a portion of air which, in obedience to the law of nature, rises to the ceiling, and would escape, if the means of escape were provided; but, in the absence of this, it soon shakes off those aerial wings, which would have carried it away, and becoming cooler and denser, it descends, and again enters the lungs of the sleepers, who unconsciously inhale the poison. When the

room has become surcharged with foul air, so that a portion must escape, then, and not till then, does it begin to escape up the chimney. Hence many persons very properly object to sleeping in a room which is unprovided with a chimney; but it is evident that such a ventilator is situated too low down to be of much service. If there be no chimney in the room, a portion of the foul air escapes by forcing its way out of some of the cracks and crevices which serve to admit the fresh air.

That this sketch is not overdrawn, must be evident to any one who, after an early morning's walk, may have returned directly from the fresh morning air into the bed-room which he had left closely shut up an hour before. What is more disgusting than the odor of a bed-room in the morning? Why is it that so many persons get up without feeling refreshment from their sleep? Why do so many persons pass sleepless nights? The answer to these and many other similar questions may be frequently found in defective ventilation. How much disease and misery arises from this cause, it would be difficult to state with any approach to accuracy, because the causes of misery are very complicated. Among the poor, the want of sufficient nourishment, neglect of temperance and cleanliness, and excessive labor, all act with aggravating effect upon want of ventilation and drainage. Among the middle classes, mental anxiety, overtasked powers, insufficient out-door exercise, are also aggravating causes; but there is a similar want of attention to ventilation and drainage. The rich suffer least, because they pass much of their time in the pure air of the country, and are relieved from a good deal of anxiety, by being independent in circumstances; their rooms are also larger and less crowded than those of the other classes; but still there is a neglect of ventilation, and they often breathe a poisonous atmosphere for hours together in the crowded and heated ball-room, the theatre, and the fashionable assembly; fainting, headache, and sickness, are not uncommon results.

A poisonous atmosphere ! The expression will not be found too strong, when we examine the ingredients of the air of an unventilated room. The products of combustion, whether they be those of the respiration of human beings, or the burning of artificial light, consist of—1. Carbonic acid; 2. Nitrogen; 3. Vapor of water, mingled with various animal products of a very offensive nature. Gas also often contains a minute portion of sulphuretted hydrogen which escapes, and a minute portion of the gas itself (carburetted hydrogen) also escapes unburnt.

Carbonic acid gas is a deadly poison. If we attempt to inhale it by putting the face over the edge of a beer vat, the nostrils and throat are irritated so strongly, that the glottis closes, and inspiration becomes impossible. In its pure state, then, it is impossible to breathe carbonic acid gas; but when this gas is largely diluted with air, it can be breathed, and the symptoms resemble those of apoplexy. Professor CHRITSON quotes a case related by M. CHOMEL, of Paris, of a laborer, who was suddenly let down to the bottom of a well containing carbonic acid diluted with air, where he remained three-quarters of an hour. On being drawn up, he was first affected with violent and irregular convulsions of the whole body, accompanied by perfect insensibility; fits of spasm, like tetanus, then came on. During the second day, these symptoms went off, and he continued afterwards to be affected with dumbness. It is especially to be noted, that, contrary to general popular belief, these effects may be produced in situations where the air is not sufficiently impure to extinguish the flame of a candle; nor does the lurking danger display itself to the sense of taste or of smell.

The danger of using charcoal as a fuel will be noticed further on; but we may here remark, that the proportion of carbonic acid necessary to produce a poisonous atmosphere is very small; so much so, that in attempts at suicide by burning charcoal in an open room, the people who have entered the apartment have found the air quite respirable,



and the choffer burning, although the person they sought was in a state of deep coma, from having been long exposed to the noxious influence.

Now, as no person would consent habitually to swallow a small portion of liquid poison, knowing it to be such, though diluted with a very large portion of pure water, so it is equally unwise to consent habitually to inhale a small portion of gaseous poison, knowing it to be such, though diluted with a very large portion of pure air; and yet this is what the majority of persons actually do who occupy apartments unprovided with proper ventilating apparatus.

Nitrogen gas, which constitutes four-fifths of our atmosphere, is not, like carbonic acid gas, a poison. Its properties are altogether inert: it will not support respiration nor combustion, simply from the absence of oxygen. An animal plunged into an atmosphere of nitrogen would die, simply because this gas is incapable of oxygenizing the blood. A flame is extinguished in this gas, simply because there is no affinity between it and the incandescent hydrogen and carbon.

The vapor given off by the lungs and the skin is charged with offensive animal effluvia, which greatly promote the contamination of the air of a crowded apartment. Doctor FARADAY expressed his opinion, in 1835, on the subject of ventilation, that—"Air feels unpleasant in the breathing cavities, including the mouth and nostrils, not merely from the absence of oxygen, the presence of carbonic acid, or the elevation of temperature, but from other causes, depending on matters which are communicated to it by the human being. I think that an individual may find a decided difference in his feelings when making part of a large company, from what he does when one of a small number of persons, and yet the thermometer give the same indication. When I am one of a large number of persons, I feel an oppressive sensation of closeness, notwithstanding the temperature may be about 60° or 65°, which I do not feel in a small company at the same temperature, and which I

cannot refer altogether to the absorption of oxygen, or the evolution of carbonic acid, and probably depends upon the effluvia from the many present; but with me, it is much diminished by a lowering of the temperature, and the sensations become much more like those occurring in a small company. The object of a good system of ventilation is to remove the effects of such air."

The effects of air, vitiated by animal effluvia, is evident in the diseases of the lower animals when crowded together in confined places. The glanders of horses, the pip of fowls, and a peculiar disease in sheep, all arise from this cause; and it is stated that, for some years past, the English nation has been saved £10,000 a year, in consequence of the army veterinary surgeons adopting a simple plan for the ventilation of the cavalry stables.

Our systems of artificial illumination have even a greater deteriorating effect upon the air of an apartment than the respiration of human beings. The leakage of a gas-pipe, or the imperfect combustion of the gas itself, in an apartment, would cause the inmates to inhale a portion of the gas. Sir HUMPHREY DAVY found, that when he breathed a mixture of two parts air, and three of carburetted hydrogen, he was attacked with giddiness, headache, and transient weakness of the limbs; but common gas is often contaminated with sulphuretted hydrogen, as the blackening of the white painted wainscoting of rooms proves, in spite of the purifying processes adopted at the gas works. This gas is the most deleterious of all the aerial poisons. It has been found by experiment, that air, impregnated with a 1,500th part of the gas, kills a bird in a short space of time; and that with about twice that proportion, or an 800th, it will soon kill a dog. This gas is emitted by cesspools and sewers, and has been a frequent cause of death when breathed in a state of concentration. "The individual becomes suddenly weak and insensible; falls down, and either expires immediately, or if he is fortunate enough to be quickly extricated, he may

revive in no long time, the belly remaining tense and full for an hour or upwards, and recovery being preceded by vomiting and hawking of bloody froth." When the noxious emanations are less concentrated, the symptoms are still very alarming; and in the dilute form, as in the emanations from the gully-holes of the sewers of London, persons inhaling them have often been attacked with sickness, colic, imperfectly-defined pains in the chest, and lethargy.

The emanations arising from the imperfect or slow combustion of oil and tallow are most injurious to health. The vapor of a smoky lamp, if disengaged in small quantities, excites intense head-ache. The fumes of the burning snuff of a candle are probably of the same nature, and are very poisonous, and every one must have remarked their penetrating nature; they fill the room the moment a candle is blown out, and their disgusting odor pervades the whole house in a very short time. Dr. CHRISTISON quotes a case in which they proved fatal: A party of ironsmiths, who were carousing on a festival day at Leipzig, amused themselves with plaguing a boy, who was asleep in a corner of the room, by holding under his nose the smoke of a candle just extinguished; at first he was roused a little each time, but when the amusement had been continued for half an hour, he began to breathe laboriously; was then attacked with incessant epileptic convulsions, and died on the third day.

In addition to all these contaminating agents, carbonic acid, nitrogen, animal effluvia, carburetted and sulphuretted hydrogen, &c., to which the air of an unventilated apartment is liable, there is yet another cause of injury to health in the disturbed electrical condition of vitiated air. This is a subject on which science has hitherto thrown no light. All that we can do is to record the fact, that pure air, such as is fit for respiration, is *positively* electric, while the air which has become impure, and consequently unfit for respiration, is *negatively* electric.

The effects of breathing an impure air have frequently

been insisted upon by medical and other writers. It is stated, that scrofulous diseases are a common result of bad ventilation, and that, in the case of silk weavers, who pass their lives in a more close and confined air than almost any other class of persons, their children are peculiarly subject to scrofula, and softening of the bones. Dr. ARNOTT stated, that an individual, the offspring of persons successively living in bad air, will have a constitution decidedly different from a man who is born of a race that has inhabited the country for a long time; that the race would, to a certain extent, continue degenerating. Defective ventilation deadens both the mental and bodily energies; it leaves its mark upon the person, so that we can distinguish the inhabitants of a town from those of the country. This witness, in alluding to the want of knowledge among all classes on the subject of ventilation, states, that he had heard at the Zoological Gardens of a class of animals where fifty out of sixty were killed in a month, from putting them into a house which had no opening in it but a few inches in the floor. "It was like putting them under an extinguisher; and this was supposed to be done upon scientific principles."

Some of the details in this report of diseases consequent on the habitual breathing of air vitiated by a number of human beings, crowded together in a badly drained and ill-ventilated part of London, are so frightful, that it is impossible to quote them here. No doubt these details refer to extreme cases among the poor and destitute; but no one will contend that the science and legislation of the day should be exerted only for those who have influence to command, or means to purchase their aid. Every one who has knowledge or wealth at his disposal, is bound to exert it as much for the benefit of his ignorant and poorer brethren as for his own pleasure and profit. There is not only a moral law requiring us to do so, but there is also a natural law, and both have this distinguishing proof of their divine origin—the<sup>67</sup> are self-acting; they confer the reward of obedience,

and inflict the penalty of transgression, with a precision and certainty which find no parallel in mere human laws and institutions. The fevers and contagious diseases arising from our neglect of the poor, find their way into our own dwellings; the miasma of our courts and alleys enters our lungs, and casts us on a bed of sickness. If, through the mercy of God, we are permitted to rise again, ought we not to practise the lesson which the penalty has been seeking to convey to us?

But not only are our dwelling houses badly ventilated, but those buildings on which the architect has lavished all his art and skill are, for the most part, entirely destitute of special means for ventilation; and are so constructed, as to render the application of such means extremely difficult, or even impossible. Such a contrivance seldom enters the mind of the architect. A building capable of holding from 800 to 1000 persons, whether it be a church, a lecture room, an assembly room, or a concert room, is, in consequence of this neglect, the too-frequent scene of much painful suffering. When such a room is crowded, and the meeting lasts for some hours, especially in winter, the consequences are sufficiently marked; "either such a multitude must be subjected to all the evils of a contaminated and unwholesome atmosphere, or they must be partially relieved by opening the windows, and allowing a continued stream of cold air to pour down upon the heated bodies of those who are near them, till the latter are thoroughly chilled, and, perhaps, fatal illness is induced; and unfortunately, even at such a price, the relief is only partial, for the windows being all on one side of the room, and not extending much above half way to the ceiling, complete ventilation is impracticable. This neglect is glaringly the result of ignorance, and could never have happened, had either the architects or employers known the laws of the human constitution."

Dr. COMBE remarks, that in churches fainting and hysterics occur more frequently in the afternoon than in the morning,

because the air is then at its maximum of vitiation. Indeed, in a crowded church, the effects of a deficient air are visible in the expression of the features of every one present—"either a relaxed, sallow paleness of the surface, or the hectic flush of fever is observable, and, as the necessary accompaniment, a sensation of mental and bodily lassitude is felt, which is immediately relieved by getting into the open air." Some persons, however, do not find this relief; the headache often lasts for hours, and ends in a bilious or nervous attack.

Our school rooms are so sadly defective in respect to ventilation, and we have known cases where, with all the windows open, a proper supply of air could not be introduced into the crowded apartment. When the weather did not allow of open windows, the atmosphere of the room was most loathsome to a visitor entering it from the fresh air. All the inmates complained of a sensation of fullness—tightness in the forehead, and headache more or less acute. Command of temper on the part of the teachers, and mental progress on the part of the pupils, are of course next to impossible under such circumstances. The writer would appeal to the experience of teachers in general, whether the slow comprehension and listlessness of children in school, who are sharp and clever on the playground, may not be traceable in a great measure to the vitiated air which they are compelled to inhale?

In curious contrast to the defective arrangements of most of our public buildings, with respect to ventilation, are our public theatres. These are, for the most part, tolerably well ventilated, or at least some attempt is made to procure ventilation, and the managers do not fail to parade the fact in their playbills at the opening of the season. They are practical men; they know that for some years past, the attention of the public has been directed to the subject of ventilation, and that a studious attention to the comfort of the house is as likely to bring people to it as attractive performances. They know, too, that people are more likely

to enjoy and applaud the business of the stage when they can breathe freely, than when the head is aching and the senses are steeped in the drowsiness of a mephitic atmosphere. Some of the methods of ventilating theatres, are clever and efficient, as will be noticed hereafter, and could easily be applied to those far more important buildings, the church and the lecture room.

The traveler, in pursuit of health, business, or pleasure, is everywhere exposed to inconvenience and suffering from want of ventilation. In our coaches, railway-carriages, and steam-boats, there are no means—or very inefficient ones—for ventilation. Many of our readers will probably be able to call to mind their nights of suffering in the heavy coaches of twenty years ago, or less.

In these introductory remarks, we do not insist upon the necessity of warming our rooms and other enclosed spaces, for that is an art which is practically well understood, and will receive a share of attention in this little work. But if warming is easy and well understood, ventilation is also easy and badly understood; that is, it is very easy to ventilate a room or a building, but the necessity for doing so is not generally admitted by the great mass of the people, nor even by those whose duty is to teach them and to provide for the practice. But to combine the two arts, to warm a room sufficiently, and at the same time to ventilate it thoroughly, is not easy, for the very means employed to ventilate a room, must necessarily dissipate and carry away the heat employed in warming it. Something, however, may and ought to be done to combine the two methods, as we shall endeavor to show; but before entering upon practical details, it is necessary to invite attention to such of the laws of heat as are more immediately connected with our subject. We can scarcely do more, in our limited space, than bring together a few of the results of scientific principles, and refer the reader to large and more comprehensive treatises for their verification.

Heat is given off from bodies by two distinct processes—*radiation* and *conduction*. In radiation, rays of heat diverge in straight lines from every part of a heated surface, and also from extremely minute depths below such surface. These rays, like rays of light, are subject to the laws of refraction and reflection, and their intensity decreases as the square of the distance. When we approach an open fire, or the surface of a stove, we feel its heat by radiation, and it has been ascertained that, at the ordinary temperature of hot water pipes, about one-fourth of the total cooling effect is due to radiation.

But the amount of radiation of a body heated above the temperature of the surrounding atmosphere depends greatly upon the nature of its surface. If a vessel of hot water, coated with lamp black, radiate 100 parts of heat within a given time, a similar vessel, containing water of the same temperature, coated with writing paper, will radiate 98 parts of heat; resin, 96; China ink, 88; red lead, or isinglass, 80; plumbago, 75; tarnished lead, 45; tin, scratched with sand paper, 22; mercury, 20; clean lead, 19; polished iron, 15; tin plate, 12.

In order to ascertain the velocity of cooling for a surface of cast iron, Mr. Hood selected a pipe of thirty inches long,  $2\frac{1}{2}$  inches diameter internally, and 3 inches diameter externally. The rates of cooling were tried with different states of the surface; first, when covered with the usual brown surface of protoxide of iron; next it was varnished black, and finally the varnish was scraped off, and the pipe painted white with two coats of lead paint. The ratios of cooling  $1^{\circ}$  were found to be for the black varnished surface 1.21 minutes; for the iron surface, 1.25 minutes, and for the white painted surface, 1.28 minutes. "These ratios are in the proportion of 100, 103.3, and 105.7; but, as the relative heating effect is the inverse of the time of cooling, we shall find that 100 feet of varnished pipe,  $103\frac{1}{4}$  feet of plain iron



pipe, or  $105\frac{3}{4}$  feet of iron pipe, painted white, will each produce an equal effect." \*

LESLIE found that tarnished surfaces, or such as are roughened by emery, by the file, or by drawing streaks or lines with a graving tool, had their radiating power considerably increased. But, according to MELLONI, the roughness of the surface merely acts by altering the superficial density, which varies according as the body is of a greater or less density, previous to the alteration of its surface by roughening. The following experiment gives the data for this conclusion: MELLONI took four plates of silver, two of which, when cast, were left in their natural state, without hammering, and the other two were planished to a high degree under the hammer. All four plates were then firmly polished with pumice-stone and charcoal; and after this, one of each of the pairs of plates was roughened, by rubbing with coarse emery paper in one direction. The quantity of heat radiated from these plates was as follows:—

Hammered and polished plate,	-	-	-	10	degrees.
Hammered and roughened plate,	-	-	-	18	"
Cast and polished plate	-	-	-	13.7	"
Cast and roughened plate	-	-	-	11.3	"

Thus it appears that the hard-hammered plate was increased in radiating power four-fifths, by roughening its surface, while the soft-cast plate lost nearly one-fifth of its power by the same process.

When a body is exposed to a source of heat, a portion of it is absorbed, and it has been proved, experimentally, that the absorptive power of bodies for heat is precisely equal to their radiative power. It was long supposed that color had great influence on radiation and absorption. By exposing variously-colored surfaces to the heat of the sun, their absorbing power was in the following order—black, blue, green, red, yellow and white. Hence it would naturally be expected, that the radiating powers of differ-

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\* *Practical Treatise on Warming Buildings, &c., London, 1844.*

ently-colored bodies would be in this order, and that by painting a body of a dark color, we should increase its radiating power. Such, however, is not the case, for the absorption and radiation of *simple heat*, or *heat without light*, depend on the nature of the surface rather than on color. Heat of low temperature, or that which proceeds from bodies of low temperature, becomes less connected with color the lower the temperature.

The numbers which represent the radiating powers of different bodies for invisible or non-luminous heat, or heat of low temperature (as given above), evidently bear no relation to color, for lamp-black and writing paper are nearly equal; Indian ink is much less, and plumbago still less. A thermometer bulb, coated with a paste of chalk, is affected by invisible heat even more than a similar one coated with Indian ink; but this result does not occur when the heat is from a luminous source. Thus it was found by SCHEELÉ that when two spirit thermometers, one containing colored, the other colorless alcohol, were exposed to the sun, the colored liquid rose much more rapidly than the colorless; but when they were both plunged into a vessel containing hot water, they rose equally in equal times.

The propagation of heat by conduction is a very different process from that of radiation. By conduction, the heat travels through or among the particles of solid matter; and is gradually communicated by one group of particles to the neighboring group, and by this to the next group, and so on, until the temperature of the body in contact with the source of heat is raised more or less above the temperature of the air. When heat is communicated to a fluid body, the process is different. In consequence of the great mobility of its particles, those which first come under the action of the source of heat, being raised in temperature, escape from its influence, and ascend through the fluid mass, distributing a portion of their acquired heat among other particles on its way; other particles immediately take

its place, and, being heated, ascend in like manner, and distribute their heat. By this process of *convection*, as it is called, the whole of the particles in a confined mass of fluid come under the action of the heating body; those first heated, escape as far as possible from the source of heat, and becoming cooled, descend again to be heated, and again to ascend and descend. In this way a circulation is maintained in the whole mass of fluid.

It is only by this process of convection that air may be said to be a conducting body, for if a mass of air be confined in such a way as to prevent the free motion of its particles, it ceases almost entirely to conduct heat, and may be usefully employed to retain heat; as in the case of double windows, the enclosed mass of air prevents the heat escaping from the apartment, and shields the glass which is in contact with the warm air of the room, from the cooling action of the external air. According to some experiments by Mr. Hood, each square foot of glass will cool 1.279 cubic feet of air  $1^{\circ}$  per minute, when the temperature of the glass is  $1^{\circ}$  above that of the external air. This, however, is in a still atmosphere. The cooling effect of external windows, when exposed to the action of winds, has not been accurately determined. It appears that the cooling effect of wind, at different velocities, on a thin surface of glass, such as the bulb of a thermometer, is very nearly as the square root of the velocity. But there are many objections to applying the results obtained from the thin glass of a thermometer bulb to the comparatively thick glass of windows. Glass is a very bad conductor of heat, and the cooling effect of wind upon it is not so great as is generally supposed.

Solids differ greatly in their heat-conducting powers. If gold conduct 100 parts of heat, platina will conduct 98.10 parts; silver, 97.30; copper, 89.82; iron, 37.43; zinc, 36.30; tin, 30.39; lead, 17.96; marble, 23.60; porcelain, 12.20; fire-brick, 11.40. The slow conducting power of such

bodies as porcelain, brick and glass, may be contrasted with the rapid conducting power of some of the metals by holding one end of a piece of each substance in a flame; the metal will soon become too hot for the hand, while the porcelain may be heated to redness in the flame without its being felt to be much warmer at the other end. A practical application of this property is also to be found in the materials of close stoves for heating apartments; for while those in which the outer case consists of copper or iron, receive their heat quickly and part with it quickly, those which are lined with brick and covered with porcelain receive their heat slowly, and communicate it slowly to the air of the apartment. Much, however, depends on the thickness of the metal casing, for, by increasing this, it will, of course, retain its heat longer.

When a heated body cools under ordinary circumstances, it is by the united effects of radiation and conduction, and the rate of cooling increases considerably, in proportion as the temperature of the heated body is greater than that of the surrounding medium. We have seen that the cooling effect of radiation depends greatly on the nature of the surface; but it is a remarkable fact, that the cooling effect of the air by conduction, has no reference to the nature of the surface; it is the same on all substances, and in all states of the surface of those substances. The air, in contact with such surfaces, robs them of a portion of heat, and immediately ascends to make way for other portions of air, which repeat the process. By these two processes the body cools down to the temperature of the surrounding air, the conductive power of which varies with its elasticity, or barometric pressure; the greater the pressure the greater also the cooling power. It has also been shown by DULONG and PETIT, that the ratio of heat, lost by contact of the air alone, is constant at all temperatures; that is, whatever is the ratio between  $40^{\circ}$  and  $80^{\circ}$  is also the ratio between  $80^{\circ}$  and  $160^{\circ}$ , or between  $100^{\circ}$  and  $200^{\circ}$ .

It was long supposed that a certain relation existed between the radiating and conducting powers of heated bodies, that the variation between them was exactly proportional to the simple ratio of the excess of heat; that is, supposing any quantity of heat to be given off in a certain time, at a specified difference of temperature, at double that difference twice the quantity of heat would be given off in the same time. This law does, to a certain extent, apply where low temperatures are concerned, but does not hold at high temperatures. Thus, in a set of experiments by Dulong and Petit, the total cooling at  $60^{\circ}$  and  $120^{\circ}$  (Centigrade), was found to be about as 3 to 7; at  $60^{\circ}$  and  $180^{\circ}$ , as 3 to 13; and  $60^{\circ}$  and  $240^{\circ}$ , as 3 to 21; whereas, according to the old theory, these numbers would have been as 3 to 6, 3 to 9, and 3 to 12. When the excess of temperature of the heated body above the surrounding air, is as high as  $240^{\circ}$  Cent., or  $532^{\circ}$  Fahr., the real velocity of cooling is nearly double what it would have been by the old theory, varying, however, with the surface.

Since the heat lost by contact of the air is the same for all bodies, while those which radiate most, or are the worst conductors, give out more heat in the same time than those bodies which radiate least, or are good conductors, it might be supposed that those metals which are the worst conductors, would be best adapted for vessels or pipes for warming rooms by radiation. "Such would be the case if vessels were *infinitely* thin; but as this is not possible, the slow conducting power of the metal (iron) opposes an insuperable obstacle to the rapid cooling of any liquid contained within it, by preventing the exterior surface from reaching so high a temperature as would that of a more perfectly conducting metal under similar circumstances; thus preventing the loss of heat both by contact of the air and by radiation, the effect of both being proportional to the excess of heat of the *exterior* surface of the heated body. If a leaden vessel were *infinitely* thin, the liquid contained in it would cool

sooner than in a similar vessel of copper, brass, or iron; but the greater the thickness of the metal, the more apparent becomes the deviation from this rule; and as the vessels for containing water must always have some considerable thickness, those metals which are the worst conductors, will oppose the greatest resistance to the cooling of the contained liquid."—*Hood*.

The reflective power of different substances for heat is inversely as their radiating power. If a surface of brass reflect 100 parts of heat; a similar surface of silver will reflect 90 parts; tin foil, 85; block tin, 80; steel, 70; lead, 60; tin foil, softened by mercury, 10; glass, 10; glass, coated with wax, 5.

When similar substances are exposed to the same temperature, they all become heated to the same degree, as measured by the thermometer; but if the temperatures of dissimilar substances have to be raised to the same degree, the quantities of heat required for the purpose will be very different for different substances. Thus, if we place side by side, upon a hot plate, two equal and similar vessels, one containing a certain weight of water, and the other an equal weight of mercury, the mercury will soon become much hotter than the water. So, also, on lowering the temperature of dissimilar substances to an equal degree, some will give out more and others less heat. Different bodies, therefore, display different degrees of susceptibility from receiving free heat within their molecules; this is called their *capacity for heat*, and the quantity required to raise equal masses or equal weights  $1^{\circ}$ , is termed their *specific heat*. The theory of specific heat is of great importance in a practical point of view, for on it depend many of the calculations for ascertaining the proportions of the various kinds of apparatus employed in warming buildings.

The specific heat of different substances can be ascertained by mixing together, with certain precautions, ascertained quantities of the substances under consideration, when

their mutual capacities for heat are determined by the decrease in the temperature of the hotter body, and by its increase in the cooler. Thus, if 1 lb. of mercury at  $32^{\circ}$ , and 1 lb. of water at  $62^{\circ}$  be mixed together, the common temperature will be  $61^{\circ}$ . The temperature of the metal has, therefore, risen  $30^{\circ}$ , while that of the water has fallen  $1^{\circ}$ . If the mercury had been at  $62^{\circ}$ , and the water at  $32^{\circ}$ , the common temperature of the mixture would have been  $33^{\circ}$ . In this case the water would have gained  $1^{\circ}$  of temperature, and the mercury would have lost  $30^{\circ}$ . Thus it appears that the capacity of water for heat exceeds that of mercury 30 times. If the water be taken as unity, the specific heat of the mercury will be  $\frac{1}{30}$  or 0.033.

Again, if 7 lb. of iron filings at  $68^{\circ}$  be mixed with 1 lb. of water at  $32^{\circ}$ , the temperature of the mixture will be  $36^{\circ}$ . That quantity of heat, therefore, the loss of which lowers the temperature of iron  $32^{\circ}$ , raises the temperature of water only  $4^{\circ}$ ; so that eight times as much heat is required to raise or depress the temperature of the water  $1^{\circ}$  as would raise or depress the temperature of an equal weight of iron  $1^{\circ}$ . Hence the specific heat of iron is  $\frac{1}{8}$ , or 0.125.

The capacity of substances for heat may also be found by observing the quantity of ice which the body under investigation is capable of thawing. Thus, if equal weights of iron and lead be operated on, it will be found that the iron requires a greater quantity of heat than the lead to produce the same change of temperature, in the proportion of nearly 11 to 3. If a bar of iron, in falling from  $100^{\circ}$  to  $95^{\circ}$ , melt 11 grains of ice, then a bar of lead of equal weight, under similar circumstances, would melt rather less than 3 grains; heat is therefore more effective in warming lead than iron. Again, an ounce of mercury and an ounce of water, in falling from  $60^{\circ}$  to  $55^{\circ}$ , will melt quantities of ice, in the proportion of 33 to 1000, or very nearly one to 30; that is, to raise water from  $55^{\circ}$  to  $60^{\circ}$ , requires a greater

quantity of heat than to raise an equal weight of mercury through the same range of temperature, in the proportion of 30 to 1.\*

The specific heat of bodies has been determined not only for equal weights, but also for equal volumes, and this is called their *relative heat*, which is to the specific heat of any substance directly as its specific gravity. It may be found by multiplying the specific heat into the specific gravity; and conversely, the specific heat may be found by dividing the relative heat by the specific gravity. Now, as the quantity of heat required to raise the temperature of 1lb. of water 1° is sufficient to raise 1lb. of mercury 30°, we say that the specific heat of mercury is  $\frac{1}{30}$ , taking water as unity; and since the specific gravity of mercury is about 13.6, it follows that the relative heat of an equal volume of this metal is  $\frac{1}{30} \div 13.6 = 0.453$ .

With respect to gaseous bodies, it has been found that their specific heat is inversely as their specific gravity or density; and, consequently, equal weights of such gases contain a larger quantity of heat, less their specific gravity. But as the relative weights of equal volumes of gas are inversely as their specific gravities, it follows that equal volumes of these gases will have equal relative heat; that is,

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\* The quantity of ice melted by different kinds of fuel, affords a convenient method of estimating their relative values. Thus it has been found that

1 lb. of coal, of good quality,	melts	90 lbs. of ice,
“ coke,	“	84 lbs. “
“ wood,	“	32 lbs. “
“ wood charcoal,	“	95 lbs. “
“ peat,	“	19 lbs. “

One method of estimating how much of the heat of a common fire is radiated around it, and how much combines with the smoke, is to allow all the radiant heat to melt a quantity of ice contained in a vessel surrounding the fire, and all the heat of the smoke to melt the ice in another vessel surrounding the chimney. By comparing the two quantities of water thus obtained with the quantities of ice melted, it will be found, according to Dr. ARNOTT, that the radiant portion of the heat is, in ordinary cases, rather less than the combined, or less than half the whole heat produced.



they will contain equal quantities of heat as the atmospheric air itself. This, however, refers to mixtures of gases, for when they are chemically combined, they have a different relative heat, which exceeds that of common air, and each such gas has a distinct index to express its relative heat, so that the quantity of heat contained in them exceeds that contained in an equal volume of atmospheric air. The capacity of atmospheric air is taken as the unit by which to estimate the specific heat of gaseous bodies; but sometimes that of water is assumed as the unit, and then the capacities of gases are comparable with those of solids and liquids. The latter values are obtained by multiplying the former into 0.2669, which is the index of the specific heat of atmospheric air compared with that of water.

The following table shows the specific heat of various substances referred to water as the standard, and are supposed to represent the quantity of heat contained in equal weights of the several substances:—

Water	-	-	-	1.0000	Carbonic acid	-	0.2210
Aqueous vapor	-	-	-	0.8470	Carbonic oxide	-	0.2884
Alcohol	-	-	-	0.7000	Charcoal	-	0.2631
Ether	-	-	-	0.6600	Sulphur	-	0.1850
Oil	-	-	-	0.5200	Wrought iron	-	0.1100
Air	-	-	-	0.2669	Mercury	-	0.0330
Hydrogen	-	-	-	3.2936	Platinum	-	0.0314
Nitrogen	-	-	-	0.2754	Gold	-	0.0298
Oxygen	-	-	-	0.2361			

It appears, however, that bodies do not possess the same capacity for heat at all temperatures, but that it increases with the temperature; the quantity of heat given out by any substance in cooling a given number of degrees, is greater at high temperatures than at low ones.

The method of ascertaining the specific heat of gases is as follows: The gas to be examined is well dried, and then brought from a vessel, surrounded with water at  $212^{\circ}$ , gradually through a spiral tube, surrounded by cold water, the gas escaping through the opposite end of the spiral. In the course of its passage, the gas parts with a portion of its

heat to the cold water which surrounds the spiral, and the temperature of the water gradually rises, until after some time it becomes stationary. The equilibrium thus established between the water and the gas is measured by a thermometer, so as to find both the rise in the temperature of the water, and the fall in that of the gas. If the experiment be made with some other gas, and the result should give a higher temperature to the water, then this second gas must have imparted to the fluid a greater amount of heat than the former one did. If, on the contrary, the temperature of water be less this time than before, it will have given out less heat, and the respective capacities for heat of these two gases will be proportional to the temperatures of the water through which they have been admitted. The capacity of atmospheric air being taken as the unit, the specific heat of other gases may be expressed by proportionate numbers. To raise 1lb. of water from  $32^{\circ}$  to  $212^{\circ}$ , requires the same quantity of heat as will raise 4lb. of atmospheric air the same number of degrees. The specific heat of air is therefore  $\frac{1}{4}$ , or, more exactly, 0.2669 that of water, as stated in the above table.

When heat is added to a solid body, the first effect which marks the increase of temperature is *expansion*; that is, the cohesive or attractive force becomes more and more opposed by the repulsive force of heat; the particles are consequently separated to greater distances, and the temperature rises. At a certain point, however, the temperature, as marked by the thermometer, becomes stationary, and although the heat be continually applied, the temperature does not rise. The solid is now undergoing a change of state; it is passing from the solid into the liquid state; and no rise in temperature will be observed until the whole of the solid has become liquid. The point at which a body begins to fuse or melt, is called its *fusing point*, or *point of liquefaction*, and is different in different substances. The quantity of heat absorbed by the body, and unaccounted

for, as far as the thermometer is concerned, is called *latent heat*. When the body is liquefied, the temperature again begins to rise, until another point is attained, when it again becomes stationary, and the liquid begins to pass off in the form of vapor or steam. This point is called the *boiling point*, and is different in different substances. The heat absorbed during the process of boiling, or vaporization, is also called latent.

If, for example, a quantity of snow, at the temperature of zero, with a thermometer in it, be placed in a vessel on the fire, the temperature will be observed to rise to  $32^{\circ}$ ; the snow will then immediately begin to be converted into water, and the thermometer will become stationary at  $32^{\circ}$ , until the whole of the snow is melted. This temperature is, therefore, the melting or fusing point of snow or ice, and the heat absorbed or rendered latent during the process, being that which is necessary to produce liquefaction, is hence called also the *heat of liquefaction*, and amounts to no less than  $140^{\circ}$ ; that is, although snow or ice may be of the same temperature as water, yet the water actually contains  $140^{\circ}$  of heat more than the solid snow or ice. As soon as the whole of the snow is melted, the temperature of the water will begin to rise, and will continue to do so until it reaches  $212^{\circ}$ , when the boiling point of water is attained. While steam is rapidly escaping, the water remains at  $212^{\circ}$ ; the heat which is absorbed, called the heat of vaporization—being that which is required to maintain water in the state of vapor or steam—amounts to no less than  $1000^{\circ}$  of temperature; that is, although water may be at  $212^{\circ}$ , and steam may be at  $212^{\circ}$ , yet the steam contains a larger amount of heat than water, such as is represented by  $1000^{\circ}$  on the scale of the thermometer.

In the following table, the melting points of a few substances are noted, together with the quantity of heat rendered latent by each in passing from the solid into the liquid state. From these, and other results, it may be seen that, in general, the higher the point of fusion, the greater

will be the quantity of heat absorbed in liquefaction. There is, however, no proportion between these effects, for ice and spermaceti melt at  $32^{\circ}$  and  $112^{\circ}$ , and yet the quantities of heat rendered latent are nearly the same.

	MEETING POINT.	LATENT POINT
Water . . . . .	32 degrees . . . . .	140 degrees
Sulphur . . . . .	213 " . . . . .	143.7 "
Spermaceti . . . . .	112 " . . . . .	145 "
Lead . . . . .	612 " . . . . .	16 "
Bees' Wax . . . . .	150 " . . . . .	175 "
Zinc . . . . .	773 " . . . . .	493 "
Tin . . . . .	442 " . . . . .	500 "
Bismuth . . . . .	476 " . . . . .	550 "

In the following table the boiling points of a few substances are given, together with the quantity of heat rendered latent by each in passing from the liquid into the aeriform state.

	BOILING POINT.	LATENT HEAT.
Water - - -	212 degrees. - - -	1000 degrees.
Alcohol (sp. gr. 0.7947) 173	" (barom. 29.5) 457	"
Ether - - -	98 " - - -	312.9 "
Oil of Turpentine - - -	314 " - - -	183.8 "
Nitric Acid (sp. gr. 1.50) 210	" - - -	550 "
Ammonia - - -	- - -	865.9 "
Vinegar - - -	- - -	903 "
Petroleum - - -	- - -	183.8 "

When water is boiling in an open vessel, the steam which escapes from it is of the same pressure and elasticity as the atmospheric air, and at  $212^{\circ}$  is equivalent to 30 inches of mercury. In a close vessel, however, the temperature of the steam may be increased to any extent, and is only limited by the strength of the vessel containing it. Thus, at  $212^{\circ}$ , the pressure of the steam is equal to one atmosphere, or 15lbs. on every square inch of surface; at  $250^{\circ}$ , the pressure of the steam, tending to burst the vessel containing it, is equal to two atmospheres, or 30lbs. on the square inch; at  $275^{\circ}$ , the bursting pressure is that of three atmospheres, or 45lbs. on the square inch, and so on. But it is a remarkable fact, that at all temperatures and pressures, the steam contains exactly the same absolute

quantity of heat; for while the temperature, as measured by the thermometer, increases almost indefinitely, the latent heat of high pressure steam diminishes in exactly the same ratio, so that the sum of the latent and sensible heat of steam always amounts to  $1800^{\circ}$  above the freezing point of water. Thus, a certain weight of steam at  $212^{\circ}$ , when condensed into water at  $32^{\circ}$ , gives out  $180^{\circ}$  of sensible heat, and  $1000^{\circ}$  of latent heat= $1180^{\circ}$ ; and the same weight of steam at  $400^{\circ}$ , condensed into water at  $32^{\circ}$ , gives out  $368^{\circ}$  of sensible heat, and  $812^{\circ}$  of latent heat= $1180^{\circ}$ . The same fact may be observed with steam at all other temperatures. These details respecting latent heat will enable the reader to compare the merits of the two systems of heating buildings by pipes filled with hot water, and by similar pipes filled with steam.

In the former system, it is not desirable to raise the water to the boiling point ( $212^{\circ}$ ) because, in such case, steam would be formed, and this escaping by the safety-pipe, would abstract much useful heat from the apparatus. In the latter system, it is desirable to maintain the pipes at  $212^{\circ}$ , because at a lower temperature, the steam would condense, and also absorb much useful heat from the apparatus. From the necessity of maintaining the temperature of  $212^{\circ}$  in steam pipes, it is evident that a given length of steam pipe will afford more heat than the same quantity of hot water pipe; but the following remarks by Mr. Hood, on the relative permanence of temperature of the two methods, will show an advantage in favor of the hot water system:

"The weight of steam, at the temperature of  $212^{\circ}$ , compared with the weight of water at  $212^{\circ}$ , is about as 1 to 1694; so that a pipe which is filled with water at  $212^{\circ}$ , contains 1694 times as much matter as one of equal size filled with steam. If the source of heat be withdrawn from the steam pipes, the temperature will soon fall below  $212^{\circ}$ , and the steam immediately in contact with the pipes

will condense; but in condensing, the steam parts with its latent heat; and this heat, in passing from the latent to the sensible state, will again raise the temperature of the pipes. But as soon as they are a second time cooled down below  $212^{\circ}$ , a further portion of steam will condense, and a further quantity of latent heat will pass into the state of heat of temperature; and so on, until the whole quantity of latent heat has been abstracted, and the whole of the steam condensed, in which state it will possess just as much heating power as a similar bulk of water at the like temperature; that is, the same as a quantity of water occupying  $1\frac{1}{16}$  part of the space which the steam originally did.

"The specific heat of uncondensed steam, compared with water, is for equal weights as .8470 to 1; but the latent heat of steam being estimated at  $1000^{\circ}$ , we shall find that the relative heat obtainable from equal weights of condensed steam and of water, reducing both from the temperature of  $212^{\circ}$  to  $60^{\circ}$ , to be as 7.425 to 1; but for equal bulks, it will be as 1 to 228; that is, bulk for bulk, water will give out 228 times as much heat as steam, on reducing both from the temperature of  $212^{\circ}$  to  $60^{\circ}$ . A given bulk of steam will, therefore, lose as much of its heat in one minute, as the same bulk of water will lose in three hours and three-quarters."

But when the water and the steam are both contained in iron pipes of the same dimensions, the rate of cooling will differ from this ratio, in consequence of the greater quantity of heat contained in the metal than in the steam. The specific heat of iron being nearly the same as that of water, the pipe filled with water will contain 4.68 times as much heat as that which is filled with steam; and if the latter cools down to  $60^{\circ}$  in one hour, the other will require about four hours and a half to do the same. There are other circumstances to be noticed hereafter, which cause the hot water apparatus to be six or eight times (instead of  $4\frac{1}{2}$ ) more efficient as a source of warmth than steam.

The process of boiling is by no means indispensable to the formation and escape of steam or vapor; for at all temperatures below the boiling point, vapor is formed at the surface of liquids, and escapes therefrom by a process called *spontaneous evaporation*. The difference between this process and ebullition is chiefly this : when a liquid boils, the vapor which escapes therefrom constantly maintains the same temperature, provided the pressure remain the same; but evaporation may go on at all temperatures and pressures, the quantity of liquid evaporated depending on the temperature and the amount of surface exposed; or the pressure may be increased or diminished, or removed altogether, without affecting the result, or that quantity of vapor which can exist in a given space at a given temperature; the saturation of that space requiring a longer time in proportion to the density of the air contained in it, while in a vacuum the saturation is instantaneous. This is the only difference.

We have seen that the pressure or elasticity of vapor at  $212^{\circ}$  is sufficient to support a column of mercury 30 inches high; the force of vapor at lower temperatures is also measured by the length of the mercurial column which it will support. Vapor at  $200^{\circ}$  will support 23.64 inches of mercury; at  $150^{\circ}$ , 7.42 inches; at  $100^{\circ}$ , 1.86 inches; at  $80^{\circ}$ , 1 inch; at  $60^{\circ}$ , .524 inch; at  $50^{\circ}$ , .375 inch; at  $32^{\circ}$  .2 inch.

The amount of evaporation, however, is greatly influenced by the motion of the air, which carries off the vapor from the surface of a liquid as fast as it is formed. A strong wind will cause twice as much vapor to be discharged as a still atmosphere. DALTON ascertained the number of grains weight of water evaporated per minute from a vessel, 6 inches in diameter, for all temperatures between  $20^{\circ}$  and  $212^{\circ}$ , when the air was still, or in gentle or brisk motion. When the water was at  $212^{\circ}$ , the quantity evaporated was 120 grains per minute, in a still atmosphere; 154 grains per minute, with a gentle motion of the air, and 189 grains per

minute with a brisk motion of the air. The following is an extract from his table between the temperatures of  $40^{\circ}$  and  $60^{\circ}$ :—

TEMP. FAHR.		FORCE OF VAPOR IN INCHES OF MERCURY.	EVAPORATING FORCE IN GRAINS OF WATER.			
			Still.	Gentle.	Brisk.	
40 deg.	-	0.263	1.05	- 1.35	- 1.65	
42 "	-	.283	1.13	- 1.45	- 1.78	
44 "	-	.305	1.22	- 1.57	- 1.92	
46 "	-	.327	1.31	- 1.68	- 2.06	
48 "	-	.351	1.40	- 1.80	- 2.20	
50 "	-	.375	1.50	- 1.92	- 2.36	
52 "	-	.401	1.60	- 2.06	- 2.51	
54 "	-	.429	1.71	- 2.20	- 2.69	
56 "	-	.458	1.83	- 2.35	- 2.88	
58 "	-	.490	1.96	- 2.52	- 3.08	
60 "	-	.524	2.10	- 2.70	- 3.30	

The amount of spontaneous evaporation is also greatly influenced by the quantity of vapor already existing in the air. In order to find this, we must ascertain the *dew point* of the air, or the temperature at which the vapor in the air begins to condense, and then, by referring to the table, the quantity of vapor in the air at the time can be found, and this, deducted from the quantity shown by the table to be given off at the ascertained temperature of the evaporating liquid, will give the quantity of water that will be evaporated per minute. In finding the dew point, we must bring some colder body into the air, or have the means of cooling some body to such a point as shall just condense the vapor of the air upon its surface. Dr. DALTON used a very thin glass vessel, into which he poured cold water from a well, or cooled down the water by adding a small portion of a freezing mixture. If the vapor was instantly condensed, he poured out the cold water and used some a little warmer, and so on, until he could just perceive a slight dew upon the surface. The temperature at which this took place, was the dew point. In DANIELL's hygrometer, the cold is produced by the evaporation of ether. Now, suppose the dew point of the air to be  $40^{\circ}$ , and the temperature of the air and of



the evaporating liquid to be  $60^{\circ}$ , with a still atmosphere, the vapor in the air, as shown by the table at  $40^{\circ}$ , is 1.05 grains; which subtracted from that at  $60^{\circ}$ , or 2.10, gives 1.5 grains per minute as the quantity of vapor given off from a surface six inches in diameter.

During the spontaneous evaporation of wet surfaces, a considerable degree of cold is produced by the quantity of heat rendered latent by the formation of the vapor, and the heat is mostly derived from the liquid itself, or the surface containing it. By proper contrivances, water may be frozen, in consequence of the abstraction of heat during the rapid formation of vapor. When a person takes cold from wearing wet clothes, the vapor from the wet clothes obtains its heat from his body, and the chilling sensation is often the greater the warmer the air. A person with damp clothes, entering a room filled with hot, dry air, is very likely to take cold, on account of the powerful effect of warm air in abstracting moisture.

In a badly ventilated room, the moisture from the breath of the inmates, and from the combustion of lamps and candles, accumulates nearly to the point of saturation. This is well shown by an experiment of the late Professor DANIELL. The temperature of a room being  $45^{\circ}$ , the dew point was  $39^{\circ}$ : a fire was then lighted in it, the door and window shut, and no air was allowed to enter; the thermometer rose to  $55^{\circ}$ , but the point of condensation remained the same. A party of eight persons afterwards occupied the room for several hours, and the fire was kept up; the temperature rose to  $58^{\circ}$ , and the point of condensation rose to  $52^{\circ}$ . Now, if this room had been properly ventilated, the vapor would have been removed as it was formed, and with it the effluvia and impure air.

In Normandy, where the cold of winter is severe, and fuel expensive, the lace-makers, in order to keep themselves warm, and at the same time to save fuel, agree with some farmer who has cows in winter quarters, to rent the close

sheds. The cows are tethered in a row on one side of the shed, and the lace-makers sit cross-legged on the ground on the other side, with their feet buried in straw. The cattle, being out in the fields by day, the poor women work all night for the sake of the steaming warmth arising from the animals.

The Laplander, during eight months of the year, inhabits a little hut with a small hole in the centre of the roof for the admission of light and the escape of smoke, and obtains heat from a smoky lamp of putrid oil, as the Esquimaux does in his hut of snow. The effect of this arrangement is, that the whole nation of Laplanders are afflicted with blear eyes. The Greenlander, indeed, builds a large hut, and contrives it better, but it is often occupied by half a dozen families, each having a lamp for warmth and for cooking, and the effect of this arrangement, says EGEDE, "is to create such a smell, that it strikes one not accustomed to it to the very heart."

The method of obtaining warmth in Persia, is scarcely an improvement on the smoky lamp of the Laplanders and Greenlanders. A large jar, called a *kourcy*, is sunk in the earthen floor, generally in the middle of the room. This is filled with wood, dung, or other combustible; and when it is sufficiently charred, the mouth of the vessel is shut in with a square wooden frame, shaped like a low table, and the whole is then covered with a thick-wadded quilt, under which the family, ranged around, place their knees, to allow the hot vapor to insinuate itself into the folds of their clothing; or, when they desire more warmth, they recline with the quilt drawn up to their chins. The immoveable position necessary for receiving the full benefit of the glowing embers is inconvenient; and the effluvia from the fuel is nauseous and deleterious. Headache is always produced, and, from the number who sleep entirely under the quilt at night, suffocation is not an uncommon accident. The *kourcy* also serves for an oven, and the pot is boiled on its embers. This

rude and unwholesome method is adopted in the noblest mansions of the cities, as well as in the dwellings of the poorer classes; only, in the former, a more agreeable fuel is burnt, and the ladies sit from morning till night under rich draperies spread over the wooden cover, endeavoring to overcome the soporific influence of the foul air by occasional cups of coffee, or the delightful fumes of the kalium.

The burning of fuel in the midst of an apartment, is by no means confined to nations whom we are in the habit of calling barbarous and uncivilized. In Seville and other parts of Spain, preparations for winter are made about the middle of October. The lower summer apartments are stripped of their furniture, and the chairs and tables are removed to other rooms on the opposite side of the court. The brick floors are covered with thicker mats than those used in the warm season. A flat and open brass pan, about two feet in diameter, raised a few inches from the ground by a round wooden frame, on which those who sit near it may rest their feet, is used to burn a sort of charcoal, made of brushwood, called *cisco*. The carbonic acid vapor is most injurious to health; but such is the effect of habit, that the natives are seldom aware of the inconveniences arising from the stifling fumes of their braziers.

The charcoal brazier is a very ancient method of warming an apartment; the Greeks and other nations commonly used it, and sought to correct the deleterious nature of the fumes, by burning costly odorous gums, spices and woods.

The braziers of the Romans were elegant bronze tripods, supported by satyrs and sphinxes, with a round dish above for the fire, and a small vase below to hold perfumes. A kind of close stove was also used; but, in either case, the smoke was so considerable, that the winter rooms were differently furnished from those appropriated to summer use. The former had plain cornices and no carved work or mouldings, so that the soot might be easily cleared away. In order to prevent the wood from smoking, the bark was

peeled off, and the wood kept long in water, and then dried and anointed with oil. It is not, however, evident how this plan should prevent the smoke of the burning fuel.

The great convenience of the brazier, and the apparent cleanliness of the fuel, are arguments in favor of its continued use even in our own day. A visitor to some of the English cathedrals, in winter, during the time of divine service, Salisbury Cathedral, for example, will be astonished to see on the floor of the choir two or three enormous braziers full of live charcoal; a peculiar odor arises from them, and pervades the building; a pleasing sensation creeps over the whole frame, and the tendency to sleep is often irresistible; persons troubled with cough cease to cough, and an unusual effort is required when the service is over, to rise and quit the building. The enormous size of the enclosure prevents any fatal effects from the abundant evolution of carbonic acid, nor have we ever heard of any well-authenticated case of injury to any one; but a very little consideration will show that, in a smaller space, such as a room, this primitive method of obtaining warmth might lead to dangerous consequences. A single pound weight of charcoal consumes in burning  $2\frac{8}{9}$  lbs. weight of oxygen, which is the quantity contained in between 13 or 14 lbs of atmospheric air. Now, a good-sized room, 20 feet by 13 feet, and 10 feet high, does not contain more than about 200 pounds weight of air, and as the combustion of one pound of charcoal produces  $3\frac{8}{9}$  lbs. of carbonic acid, which, by mingling with the rest of the air of the apartment, renders at least 36 lbs. weight of air unfit for respiration—making in all about 50 lbs. weight of air—it follows that, in such a room, the air will require, for healthy respiration, to be renewed many times an hour.

In addition to the brazier, the ancient Romans were acquainted with flues for warming rooms and buildings; but as these were costly contrivances, their use was confined to the wealthy. These flues, forming what was called the *hypocaustum*, were conducted below the floor of the room

intended to be warmed. The hypocausts were of two kinds—the first, constructed with flues running under the floor, and heated from a fire-place on the outside of the building; and the second kind formed like a low chamber, having its ceiling supported by small pillars or by dwarf walls, and sometimes with flues leading from them to other apartments.

The hypocaustum is well known to the Chinese, and is in common use about Peking, where the winter climate is very severe. The houses of the better class are built with double walls, and with hollow flues extending beneath the floors. The fire-place is constructed either against the exterior wall of the apartment to be heated, or in an inferior room adjoining; by which means the annoyance from dust and smoke are avoided, as well as the inconvenience of servants entering the room to attend to the fire. From the fire-chamber proceeds a main flue, which is connected with the horizontal flue. From this another flue proceeds at right angles to about three-fourths of the extent of the room; these flues are perforated with holes at proper distances, in order to give out the smoke and heated air equally over the whole area of the flooring. Two horizontal flues are built in or attached to the side walls, in order to carry off the smoke into the external air. The flooring of the apartment consists of flat tiles or flag-stones, neatly embedded in cement, so as to prevent the escape of the smoke or heated air from the flues beneath into the room. These stones or paving-tiles, resting on blocks of stone or bricks, may be of any thickness required for the extent of the air-flues which are employed. By this contrivance, the heat, coming in contact with every part of the floor, is uniformly diffused over the apartment. The floors, also, being very imperfect conductors of heat, being once sufficiently heated by the flues, and the apertures of the main flues outside being stopped, retain a sufficient heat for domestic comfort during many hours. The paving-tiles of

the rooms are often made of ornamental porcelain ware of considerable thickness. Even the benches and sleeping-places are warmed by this contrivance. These are built hollow, with bricks, in the form of a square bench or oblong bed, and communicating with the flues, or having their own separate flue, are thus heated. Those who dislike lying on the hot bricks, or on the felt mat that is spread over them, suspend from the ceiling, over the heated bench, a kind of hammock, made of coarse cloth; and thus they enjoy warmth and repose. In the morning, the bed-places are covered with carpets and mats, on which the inmates of the house sit.

The ingenious economy of the Chinese (from which we might often borrow a useful lesson), prevents the flues from becoming choked by soot. Instead of employing pit-coal of good quality, they make use of the inferior or small refuse coal for this purpose, and mix it with a compost of clay, earth, cow-dung, or any refuse vegetable matter; and then form it into balls, which are dried in the sun or open air. This method is not adopted on account of any scarcity of fuel, for coal is abundant in China; but the Chinese know how to take care of it. They find that their fire-balls, during combustion, give out very little smoke; and they are largely manufactured in the coal districts, and distributed by canal carriage over a large portion of the empire.

In the inferior class of houses, instead of having the fire outside the house or room to be heated, it is built in the corner of the dwelling-room. A pit is dug for the body of the fire-chamber and draught-hole; and the top, or head of the stove, is used for the different operations of cooking.

That no portion of heat may be lost, or escape into the room directly from the fire, beyond what is necessary to maintain a given temperature, vessels of water are placed on the head of the stove, and thus the heat, which would otherwise be lost, is absorbed and economized; while it affords, by its evaporation, the necessary supply of moisture

to preserve the atmosphere of the room in a healthy condition as to moisture.

The Chinese call a stove which is heated by a furnace, a *kang*; the *ti-kang* is a furnace of which the flue runs under the floor or pavement of a room; and the *kao-kang* is that used for heating benches and beds. There is yet a third variety, *tong-kang*, which is formed in the wall, and this differs from the *ti-kang* only in being perpendicular instead of horizontal. In the *tong-kang*, the heating-flue is carried along the floor, with openings from it, at which the heated air and smoke ascends into the spaces of a hollow wall.

The necessity for providing for the exit of smoke seems to have caused the invention of the chimney.

Chimneys appear to have been common in Venice about the middle of the fourteenth century. An inscription over the gate of the school of Santa Maria della Carita states, that in 1347, a great many chimneys were thrown down by an earthquake—a fact which is confirmed by JOHN VILLANI, who refers the event to the evening of the 25th of January. Chimneys had also been in use at Padua before 1368, for in that year GALEAZO GATARO relates, that FRANCISCO DA CARRARO, lord of Padua, came to Rome, and finding no chimneys in the inn where he lodged, (because at that time fire was kindled in a hole in the middle of the floor,) he caused two chimneys, like those that had been long used in Padua, to be constructed by the work-people he had brought with him. Over these chimneys—the first ever seen in Rome—he affixed his arms, which were remaining in the time of GATARO. Winwall House, in Norfolk, which has been described as the most ancient and perfect specimen of Norman domestic architecture in the kingdom, has not only recessed hearths, but flues rising from them, carried up in the external and internal walls. Now, if Winwall House really be an Anglo-Norman edifice, its chimneys must have been built in the twelfth century, and, consequently, the claim of the Italians to the invention cannot be supported. The chim-

neys at Kenilworth and Conway were also probably erected anterior to the date of those on which the Italians rest their claim. LELAND, also, in his account of Bolton Castle, which he says was "finiched or Kyng Richard the 2 dyed," notices the chimneys. "One thyng I muche notyd in the hawle of Bolton, how chimeneys were conveyed by tunnells made on the syds of the walls betwyxt the lights in the hawle, and by this means and by no covers, is the smoke of the harthe in the hawle wonder strangely conveyed."

In all places where wood exists in abundance, coal is not sought after for the purposes of domestic fuel. To show the objections raised to everything new, it may be stated, that when coal was first generally used in England, it was supposed that the fumes of coal had a peculiarly corrupting effect upon the air, and were most injurious to health. Its value, was appreciated by brewers, dyers, smiths, and others, whose occupations lead to the consumption of a large quantity of fuel, and towards the close of the thirteenth century, coal was imported into London from Newcastle, for the use of those trades. In 1306, however, parliament petitioned the king to prohibit the use of the noxious fuel in the city. A proclamation was accordingly issued, prohibiting the use of coal; and as this failed in its effect, a commission was issued for the purpose of ascertaining who burned sea-coal within the city and its neighborhood, and to punish them by fine for the first offence, and by the demolition of their furnaces if they persisted. But even these severe proceedings failed to put down the nuisance. A law was therefore passed, making the burning of sea-coal within the city a capital offence, and permitting its use only in the forges of the neighborhood. In the reign of the first Edward, a man was tried, convicted, and executed, for burning sea-coal in London. Even in districts where coal abounded, it was not used as a domestic fuel; for we read that in 1349, in the religious house at Whalley, peat, with a very little wood, was the only fuel used.



So deeply rooted was the prejudice against coal, that it was not until the commencement of the seventeenth century that its use became more general. Ladies had an idea that a coal fire injured their complexions, and they would not even enter a house or room where the obnoxious fuel was used; nor would they even partake of meat which had been roasted at a coal fire. When BEX JONSON had to entertain a party of guests at his house, he warmed his room with a charcoal fire; but, on ordinary occasions, he used coal; for we find that, on more than one occasion, his flue caught fire from an accumulation of soot.

There was, doubtless, good reason for the objections of our ancestors to the use of sea-coal, for the chimney fire-places were usually made in the form of a large square recess, and the breast of the chimney was of the same size as the recess itself. In order to rid sea-coal of its noxious sulphurous vapor, Sir JOHN HACKET and OCTAVIUS DE STRADA proposed, in 1626, to convert the coal into coke, and thus make it as agreeable a fuel for chambers as wood and charcoal. A patent was obtained for the purpose, but the speculation did not succeed, as the vapor given off by the coke was found to be nearly as unpleasant as that from coal.

About this time, a great improvement was made in France in fire-places. LOUIS SAVOR, in his *Treatise on Architecture*, remarks that large rooms only are free from smoke, and that when fires are made in small apartments, a door or a window had to be left open, or else the air came down the wide flue, and drove the smoke into the room. To correct this defect, he raised the hearth about four inches, and lowered the mantel so as to make the opening of the fire-place about three feet high. The width between the jambs was reduced to three feet; the jambs from the mantel were to be carried up sloping to the waist, or where the flue begins to be of uniform width, and the opening of the fire-place was formed like an arch. But, where the fire-place could not be conveniently altered, SAVOR perforated with small holes a plate

of iron, whose width and length was nearly equal to the hearth, and this was fixed three inches above the tiles of the common hearth. On this perforated plate he placed a *grille de fer* of the same length as the billets to be burned, and raised nine inches above the plate; the wood was placed on the grate, the charcoal on the perforated plate, and the hearth received the ashes. The air, rising through the small holes, made the charcoal burn briskly, and this so much assisted the burning of the wood, that a rapid draught up the chimney was established, and smoke prevented.

About the year 1658, the project for burning coke, instead of coal, was revived by Sir JOHN WINTER, who invented an improved fire-place for the purpose. The cradle, or fire-cage, was placed on a box about eleven inches high, in the front of which was an opening, fitted with a door, which was always kept closed, except when the ashes were removed. A pipe, inserted into the side of the box, communicated with the external air, at a level of two or three feet below the bottom bars of the fire-cage. This pipe could be closed at pleasure by a valve. When the coke, or charcked coal in the fire-cage did not burn well, the valve was opened, and the air from the outside rushed in a strong current into the box, and, by its powerful blast, soon roused up the fire; the valve was then closed, and all communication with the external air was thus cut off. The flue was closed with an iron plate or register, that moved on a hinge. It had an opening, 8 inches square, for carrying the smoke into the chimney, and this was found large enough for a fire-place of any dimensions. This ingenious contrivance does not seem to have succeeded, although both it and the arrangement described by SAVOR have, with slight variations, been brought forward several times within the last three-quarters of a century, and patented as notable inventions.

In 1678, Prince RUPERT invented a fire-place, so contrived that the draught took a downward direction before entering the flue

"The fire-cloth," says Mr. BERNAN, "was a common appendage to a fire-place, particularly where wood was burned, for then the flue was large, the hearth wide and low, and the mantel high; when the chimney smoked, in certain winds only, the cloth was suspended from each corner of the mantel-piece. But when the disease was unremitting, the curtain was fixed by rings, running on a rod that went across the fire-place. When not used, it was drawn to one side, like the curtain of a cottage window. Very often the fire-cloth was contrived to be drawn up like a modern Venetian blind, and made so deep, as to reach from the mantel to the hearth, and serve the office of a fire-board, when there was no fire in the yawning chimney. The first variety of smoke-cloth was seldom more than fifteen inches deep, and was frequently made of painted leather; but in good houses, the suspended fire-cloths were usually of damask and tapestry. None of these contrivances are yet extinct."

In 1680, a stove was exhibited at the fair of St. Germain, near Paris, in which the smoke not only descended, but was also consumed. It is formed of hammered iron, and stands on the floor of the room. The fuel, wood, or coal, is contained in a vase, with a grating at the bottom, and this vase is placed on a box or cylinder, from which a pipe is carried into a flue, which has no communication with the hearth recess, nor with the air, except at the top, above the roof. The vase being filled with fuel, some dry brushwood is placed upon it. The upper part of the pipe is then heated by a lamp, or hot iron, in order to establish a current of air from the cylinder, which current passes down through the fuel in the vase. A piece of lighted paper is then placed on the brushwood, and the downward current carries the flame downwards, first igniting the wood and then the coals, and consuming the smoke in descending. The products of combustion thus carried into the cylinder, rise through the pipe into the

chimney. The descending current may be made evident by holding a flame over the vase, and it will be drawn downwards. JUSTEL, who described this arrangement to the Royal Society in 1681, says, that "the most fetid things, matters which stink abominably when taken out of the fire, in this engine make no ill scent; neither do red-herrings broiled thereon. On the other hand, all perfumes are lost, and incense makes no smell at all when burned therein." An improved edition of this stove was made by Dr. FRANKLIN.

A very economical method of heating two rooms by one fire is described by SAVOT. A plate of iron is made to separate the fire-places of the two adjacent rooms. A fire made on the hearth heats the plate, and this, in its turn, by its radiation, warms the air in the adjacent room, as effectually as a stove would do, provided its flue is properly closed. Or if the second room have no chimney, it may still be warmed by making an opening in the wall, at the back of the fire-place, and closing it with an iron plate. When Dr. FRANKLIN was in Paris, he saw an example of this contrivance, and estimated it highly.

In all these early contrivances there is much ingenuity, and we bring them forward thus prominently, because they are really the legitimate ancestors of many reputed modern inventions, whose authors are either ignorant of, or have failed to acknowledge, their legitimate descent therefrom. Inventors would often be spared much anxiety and expense, if they would condescend to study the subject to which their invention refers, before they introduce to the public a contrivance which may have been as well if not better done a long time before. Inventions, whether in the fine arts, or in the useful arts, require genius often of a high order; and although it is not expected that every inventor should have the genius of WARR, it is at least required that they should possess some of his method of patient research.

But there is one writer whose inventions have especially

served as the type of many a modern fire-place, and at the time of its publication in 1713, showed a great and sudden advance in the art of warming apartments. The author of the treatise referred to is no less a man than the Cardinal POLIGNAC, who, under the assumed name of GAUGER, published a treatise, entitled "*La Mécanique du Feu, ou l'Art d'en augmenter les effets et d'en diminuer la dépense, contenant le Traité de Nouvelles Cheminées qui chauffent plus que les Cheminées ordinaires, et qui ne sont point sujettes à fumer.*" This treatise was reprinted at Amsterdam in 1714, and a translation of it, by Dr DESAUGULIERS (from which we are about to quote), was published in London in 1716.

In the preface, the author has some sensible observation: on the subject of warming and ventilation. After remarking that persons who judge of the value of machines by their complication, will not find his inventions to their taste. He bestows a complaint on those who estimate "such devices from the simplicity of their construction, and the facility of their execution," and then proceeds thus:—"A plate of iron or copper bowed or bended after such a manner as is not at all disagreeable to the sight; a void behind, divided by certain small iron bands or partition plates, forming several spaces that have communication one with another; a little vent-hole in the middle of the hearth, a register plate in the upper part of the funnel: and for some shafts, a capital on the top, make up the whole construction and workmanship of our modern chimney. Now, can there be anything more simple or plain, or more easy to execute?"

"To be able to kindle a fire speedily and make it, if you please, flame continually, whatever wood is burning, without the use of bellows; to give heat to a spacious room, and even to another adjoining, with a little fire; to warm one's self at the same time on all sides, be the weather ever so cold, without scorching; to breathe a pure air, always fresh, and to such a degree of warmth as is thought fit; to be never annoyed with smoke in one's apartment, nor have any

moisture therein; to quench by one's self, and in an instant, any fire that may catch in the funnel of a chimney; all these are but a few of the effects and properties of these wonderful machines, notwithstanding their apparent simplicity. Since I used this sort of chimney, I have not been troubled one moment with smoke, in a lodging which it rendered before untenable as soon as a fire was lighted. I have always inhaled, even during the sharpest seasons, a fresh air like that of the spring. In 1709, water that froze hard everywhere else very near the hearth, did not congeal at night in my chamber, though the fire was put out before midnight; and all that was brought thither in the day soon thawed; neither did I ever perceive the least moisture in winter, not even during thaws."

The treatise opens with the following remark:—"It seems that those who have hitherto built or caused chimneys to be erected, have only taken care to contrive in the chambers certain places where wood may be burnt, without making a due reflection that the wood in burning ought to warm those chambers, and the persons who are in them; at least, it is certain that but a very little heat is felt of the fire made in the ordinary chimneys, and that they might be ordered so as to send forth a great deal more, only by changing the disposition of their jambs and wings."

A number of complicated varieties of fire-place are described in this treatise, all of which are furnished with parabolic jambs and the soufflet; but the back, the jambs, the hearth, and the mantel, were also made hollow, for the purpose of pouring a copious supply of heated air into the apartment. These hollow spaces, named *caliducts* or *meanders*, are in one arrangement formed by perpendicular divisions. In another variety they are horizontal. In this variety the hearth is also hollowed out, and divided into a series of square spaces.

A simple, but highly ingenious grate, in which the burning fuel was made to consume its own smoke, was one of the

many original contrivances of FRANKLIN. It consisted of a circular fire-cage, about a foot in diameter, and from 6 to 8 inches wide from front to back. The back is of plate-iron, and the front filled with bars, of which the three middle are fixed and the top and bottom moveable, and either one may be drawn out for the purpose of filling the grate with fuel. The fire-cage turns upon axes, supported by a crochet, fixed on a stem, which revolves upon a pivot fixed to the hearth. The fire is lighted by withdrawing the upper bar and then placing wood and coals in the cage, as in a common grate; the bar is then replaced. So, also, in adding fresh fuel, the upper bar is removed and then replaced. When the grate is first lighted, a quantity of thick smoke is emitted by the fuel; but, as soon as it begins to burn well, the cage is turned round on its axes, so that the burning coals at the bottom shall occupy a position at the top. The whole is then turned round on the pivot, so as to bring the bars again in front; by this arrangement the fresh coals below the lighted fuel will gradually ignite, and their smoke, having to pass through the fire above them, will be entirely consumed. In this way the combustion is perfect, or nearly so, and this economy of fuel is accompanied by a much greater heating effect; little or no soot is deposited, for all the combustible matter of the fuel is converted into heat. For want of some such contrivance, a very considerable portion of our fuel is wasted by our open fires, under the best management. Soot is very inflammable, and one pound of it gives as much, if not more heat, than one pound of coal; and the quantity of soot which lines our chimneys, when bituminous coal is used, is very inconsiderable, compared with that which escapes unconsumed at the chimney-top, and fills the neighborhood with *blacks*, and returning into our houses through the open windows, makes the furniture dirty, or, entering our lungs, offers an impediment to free respiration. Another advantage of the revolving grate is, that it may be turned into any

position, so as to radiate its heat in one direction rather than another; and, by placing the bars in a horizontal position, a tea-kettle, or other cooking utensil, may be conveniently set on it.

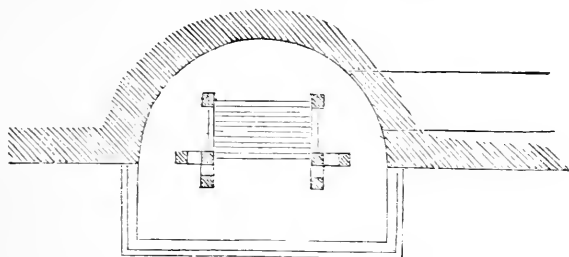
COUNT RUMFORD deserves honorable mention as an improver of grates, and an economizer of fuel. The *Rumford* *stove* has made his name familiar among all classes, and is so well known, that a description is unnecessary. The Count's essential improvement consisted in contracting the area of the fire-chamber, and placing a flat surface in each interior angle, so as to reflect that portion of heat into the room, which in the old square-chambered grates escaped up the chimney. The throat of the chimney was also greatly reduced in size, and the breastwork rounded off, in order to afford less obstruction to the ascent of the smoke. When the chimney required sweeping, the plate or flag-stone could be removed so as to open the throat, and be replaced after the operation. According to RUMFORD, in order to obtain the greatest effect from the fuel, the sides of the fire-place ought to be placed at an angle of  $135^{\circ}$  with the back of the grate; or, which is the same thing, at an angle of  $45^{\circ}$  with a line drawn across the front of the fire-place. These angular covings were not to be of iron, but of some non-conducting substance, such as fire-clay, and polished with black-lead. He objected to circular covings, on the ground that they produced eddies or currents, which would be likely to cause the chimney to smoke; and he also objected to the old form of registers or metal covers to the breast of the chimney, for the same reason; and also because, by their sloping upwards, towards the back of the fire-place, they caused the warm air from the room to be drawn up the chimney, and thus interfered with the passage of the smoke. These registers are now arranged so as to be lower at the back than at the front of the stove, but they are usually placed too high up. If brought down lower and placed at an angle of  $45^{\circ}$ , much of the heat of the fire would be reflected into the room.



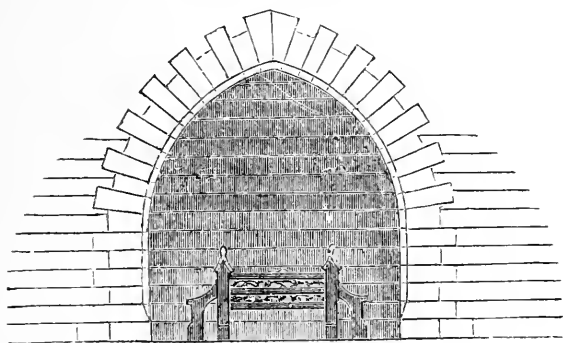
The Count also greatly diminished the size of the fire-grate, and considered the best proportions for the chimney-recess to be, when the width of the back was equal to the depth from front to back, and the width of the front or opening between the jambs three times the width of the back.

“ Although the best form for register stoves has now for several years past been adopted, the desire for novelty has caused the true principles of construction to be frequently departed from; and we accordingly find, in the most modern stoves, considerable deviations from these principles.”

An economical mode of forming the living-room *fire-place* and stove, is shown in the annexed drawings. The chimney-jambs, arch and back, are formed of bricks glazed on the outer surface, which would have a very neat and clean appearance. The plan shows the back of the fire-place as



PLAN OF COTTAGE LIVING-ROOM FIRE-PLACE.



ELEVATION.

circular, with the grate placed as far forward and as nearly in the focus of the reflecting surface as possible. The chimney-mouth should be small, and provided, where the cost will allow of it, with a register-flap, to regulate the draught. The fender may be formed with stone or earthenware. The grate is shown of a simple construction, and may be rendered still more so by forming the supports of bricks or tiles.

We think we have now indicated all the various families of open fire-places, at least as far as their principles are concerned. The species are innumerable, and it would be impossible, in our limited space, to give even a list of them. Those who desire further information on the subject, are referred to Mr. BERNAN's entertaining little volumes. But as the subject of open fires is closely connected with that of smoky chimneys, it may be useful to introduce a few details respecting this complaint and its cure.

Science often follows as well as precedes the useful arts. In the former case, she has to correct defects; in the latter case, the progress of those arts depends on her own improvement. The invention of chimneys was not a scientific result, but an act of necessity. The first object proposed to be accomplished by them was to discharge into the air the products of combustion, instead of allowing them to spread over the apartment. With the huge wood fires of our ancestors, the large hearth recess and the capacious flue did not interfere with the accomplishment of the object proposed; but as circumstances changed—when fire-places were introduced into small rooms, and coal was substituted for wood—the arrangements which were then suitable did not apply. Science was unable, or did not condescend, to investigate the subject, and thus the defects of chimneys continued to exist through many generations. One great defect arose from the great capacity of the flue in proportion to the extent of the fire, the heat of which was often insufficient to determine an upward cur-

rent for carrying off the smoke. It is now a matter of everyday experience, that the force of the draught in a chimney is so much the greater as the column of air which passes up it is longer or more heated; or, in other words, the taller the chimney, or the hotter the fire, the more rapid will be the draught. The ascensional force of this current is the difference between the weight of the column of heated air in the chimney, and a column of the surrounding atmosphere of equal height. The draught, therefore, is increased by increasing the perpendicular height of the chimney. Its length in a horizational direction does not increase, but diminishes the draught, by cooling the air before it gets into the effective part of the flue. The draught is also increased, by making all the air which enters the chimney pass through or very near the fuel; for when much air gets into the chimney above the fire, by having a high mantel-piece, the mass of air in the chimney cannot get sufficiently heated.

It is a law of expansion for atmospheric air and all gases, that they dilate almost equally and very nearly in proportion to the increase of temperature. According to GAY LUSSAC, 1,000 cubic inches of air at the freezing temperature increase in bulk to 1,375 cubic inches at the temperature of boiling water. For an increase of temperature, therefore, from  $32^{\circ}$  to  $212^{\circ}$ , amounting to  $180^{\circ}$ , the increase of volume is 375 parts in 1,000, or  $\frac{3}{8}$  of the whole bulk; and since the expansion is uniform, the increase of volume for  $1^{\circ}$  will be found by dividing this by 180, which will give an increase of  $20\frac{5}{8}$  parts in 10,000 for  $1^{\circ}$  of Fahrenheit's thermometer. The recent experiments by MAGNUS and REGNAULT have thrown a doubt on the correctness of this result. By methods perfectly independent of each other, these philosophers have arrived at 0.3665, instead of 0.375, as the true co-efficient for the expansion of atmospheric air.

Now, as this law of expansion applies equally to air in

motion as to air in a state of rest, we can thus calculate the amount of dilatation undergone by the column of air in a chimney from the heat of the fire in the grate. But as the heat is constantly varying, so also is the volume of ascending air. The air of the room which passes through the fire and undergoes a chemical change is intensely heated, and passing up the flue becomes reduced in temperature at every step. The air which rushes into the cavity above the fire becomes also suddenly expanded, rises, and mingling with the heated gaseous products of combustion, diminishes somewhat of their temperature, while it augments their bulk. The mean temperature of the heated ascending column may be found by taking the temperature a short distance above the burning fuel, and also at the top of the chimney; by adding these two results together, and dividing by two, we get the mean temperature, or a near approximation thereto. We are then able to calculate the force of the draught by applying one of those rules which scientific men have formed for the purpose. The method of calculation proposed by MONTGOLFIER is very simple, and appears, from recent inquiries, to be accurate. It is this: Ascertain the difference in height between two equal columns of air when one is heated to a certain temperature, the other being the temperature of the external air—and the force of the draught, or the rate of efflux, is equal to the velocity that a heavy body would acquire by falling freely through this difference of height. Now, the space through which a heavy body falls in perpendicular height in one second is rather more than sixteen feet; but by the law of accelerating forces, the velocity of a falling body at the end of any given time is such as would carry it, in an equal time, through twice the space through which it has fallen in that time; or the velocity, in feet per second, is equal to eight times the square root of the number of feet in the fall; or, to the square root of the number obtained by multiplying 64 by the height of the fall in feet.

When the force of the draught of a chimney is the difference in weight between two columns of air caused by the expansion of one of these columns by heat, the decimal .00208 which represents the expansion of air by  $1^{\circ}$  of Fahrenheit, must be multiplied by the number of degrees the temperature is raised, and this product again by the height of the heated column.

The mean temperature of the heated ascending current in a chimney is much greater than  $20^{\circ}$  above that of the colder column with which it is compared; but it is most probable that air expands more proportionally at high temperatures than at low ones for equal increments of heat. As the law of expansion for high temperatures has not, as far as we know, been determined, it was thought better to select an example within the range of our knowledge, than to assume a higher temperature, which would more nearly represent the conditions of the case.

By the same means, the efflux of air, under any given pressure, can also be calculated. The pressure being known, we calculate the height of a column of air equal in weight to this pressure.

In these cases, however, there must be an allowance for loss by friction, which will vary according to the nature and size of the chimney-shaft, and also with the velocity of the air. The retardation of the air by friction, in passing through straight tubes, will be directly as the length of the tube and the square of the velocity, and inversely, as the diameter.

In this way the action of chimneys is brought within the domain of science. There are, however, practical difficulties and special cases which usually come under the pathological treatment of the smoke-doctor; these may all be resolved by reference to well-known scientific principles; but, unfortunately, the smoke-doctor is not always—indeed very seldom—a man of science. The following cases of smoky chimneys and the method of cure, will include as much as need be said on this subject to the intelligent reader.

Chimneys may smoke for want of a sufficient supply of air. This is sometimes the case in a new house, where doors and windows fit tightly and accurately, so that scarcely a chink is left for the admission of air. Or if the house be not new, the windows and doors are often lusted, sandbags are placed over the junction of the two window-frames, and a thick mat closes the bottom of the door, and even the key-hole is often stopped. It is no wonder that, under such circumstances, the chimney should smoke; for the air necessary to support the fire must come down the chimney (the only way left for it) instead of passing through the fire and up it.

To ascertain, in a rough way, how much air is required per minute to make the fire burn well without smoking, set the door open until the fire is burning properly, then gradually close it until smoke again begins to appear. Then open it a little wider and hold it in such a position as will admit the necessary supply. Now observe the width of the open crevice between the edge of the door, and the rabbet into which it would shut. Suppose this distance to be half an inch in a door eight feet high; the room would, in such case, require for the entrance of the air an aperture equal to 48 square inches, or a hole six inches by eight inches. This, however, would be more than is usually required. Dr. FRANKLIN found that a square opening of six inches to the side, was a good medium size for most chimneys. But now comes the difficulty (at least in English houses, where no air-duct is provided by the architect and builder, as in the POLIGNAC fire-place), where to make this opening. If made in the door, it not only interferes with the privacy of the room, but admits of cold draught to the back and feet of those sitting near the fire; if made in the window, it brings a cataract of cold air down upon the heads of the inmates.

It has been proposed to cut a crevice in the upper part of the window-frame, and to place below this a thin shelf, sloping upwards, in order to direct the air towards the ceiling, where, mingling with the heated air of the apartment,

it would mitigate its temperature, and bring it down again to feed the fire. The objection to this plan is, that it would cool the room; but as fresh air admitted from any other source would have a similar cooling effect, it is not easy to propose a better plan. An old-fashioned contrivance for kitchens, was to place in one of the spaces of the window-frame a circular tin plate, containing a wheel mounted on an axis, the radii or vanes being bent obliquely; these being acted on by the entering air, forced it round like the vanes of a wind-mill, and at the same time dispersed the air to a certain extent, and prevented a distinct draught from being felt. Another method was to take out a pane of glass and substitute a tin frame, giving it two springing angular sides, and being furnished with hinges below, it could be drawn in more or less above, so that the incoming air might be directed upwards, and regulated as to quantity. A contrivance has lately been introduced for ventilating rooms, but when there is a fire in the room, it must serve the purpose of introducing air instead of letting it out. It consists of a number of strips of plate glass, arranged after the fashion of a Venetian blind, occupying the position of one of the panes of glass in the upper window-frame. By a little adjusting motion, the strips can be separated more or less apart, to regulate the supply of air, or closed entirely, so as to exclude it. Perforated panes of glass have also been introduced as ventilators, but they must also bring air into the room instead of letting it out, when a fire is burning.

A second cause of smoky chimneys arises from the size of the fire-place; it may be too wide or too high. Dr. FRANKLIN recommended that the openings in the lower rooms should be about 30 inches square and 18 deep; and those in the upper rooms only 18 inches square and not quite so deep; the intermediate openings diminishing in proportion to the height of the funnel.

But the funnel itself may be too high compared with the size of the fire. The hot air ascending to a certain height

may distribute its heat to the air in the upper part of the flue, so that the whole may cool down, and the column within the flue be nearly of the same weight as an equal column on the outside. In such a case there will be little or no draught to carry off the smoke, and it will, therefore, enter the room.

But it more frequently happens that the funnel is too short. The remedy, in such a case, is to contract the opening of the chimney, so as to force all the air that enters to pass through or very near the fire.

In some houses, instead of having a separate chimney for each room or fire-place, the flue is bent or turned from an upper room into the flue of another fire from below. In such a case, the upper chimney is too short, since the length can only be estimated from the place where it enters the flue of the lower room; and this, in its turn, is also shortened in efficient length by the distance between the entrance at the second funnel and the top of the stack; for all that part being supplied with air from the second funnel, adds no force to the draught; and if there is no fire in the second chimney, it cools the hot current of the first, and so diminishes the draught. The remedy, in this case, is to close the opening of that chimney in which there is no fire.

Chimneys often overpower each other, and so cause them to smoke. If, for example, there are two fire-places in one large room, with fires in each, and the doors and windows closed; if the two fires do not burn equally well, either from not being lighted at the same time, or not equally supplied with fuel, or from any other cause, the stronger fire will overpower the weaker, and draw the air down its funnel to supply its own demand. The air descending the funnel of the weaker fire brings the smoke with it, and thus fills the room. Two chimneys in different rooms, which communicate by a door, may also act in this way whenever the door is opened; so, also, in a house where all the doors and windows fit tightly, a strong kitchen chimney



on the lowest floor may overpower any other chimney in the house, and draw air and smoke into the rooms as often as a door communicating with the staircase is opened. Dr. FRANKLIN mentions the case of a nobleman's house in Westminster afflicted with this troublesome complaint. It was a new house, and after the owner had paid for it, and discharged all claims, he had to expend £300 more before the smoky chimneys were cured. Of course, the only remedy for this disorder is, to provide each room with the means of furnishing the fire-place with a sufficient supply of air for the combustion of the fuel. When will architects and builders be convinced of the fact, that fire-places, as well as human beings, require constant supplies of fresh air, and that it is their duty to provide every room with air-channels, placed so as to feed the fire without annoying the inmates?

Another fruitful source of smoky chimneys is, when their tops are commanded by higher buildings, or by a hill, so that the wind blowing over them, falls like water over a dam, sometimes almost passing over the tops of the chimneys, and beating down the smoke. If the funnels cannot be raised, so that their tops may be of the same height or higher than the eminence, the only remedy is to mount one of those ugly contrivances with which the chimney-doctors delight to satirize the architect and builder, and which are thus enumerated by an amusing writer in *Chambers's Edinburgh Journal*:—"The simplest of all consists in the well-known revolving bonnets, or cowls, with wind-arrows on their summits; which, by the way, were once called Bishops, in Scotland, while a friend assures me, that in the west of England he has heard them called Presbyterians. The philosophy of this contrivance is sufficiently simple: in whichever direction the wind blows, the mouth of the chimney is averted from it. This principle has its development in a thousand devices—some looking like Dutch-ovens come up to see the world; some like half sections of sugar-loaves;

some like capital H's, and sundry other pleasing objects. The red chimney-pots, too, have contrivances of a similar intention, in the diverging spouts and cavities and twists which some of them delight in. A different species, is the perforated whirling variety, which seem perpetually whizzing round, for the mere fun of the thing, since any good they do is extremely apt to escape detection. They are a lively-looking apparatus; but on squally nights, and when the pivot becomes a little rusty, the musical sounds they give forth can scarcely be considered agreeable. Among the more ingenious of smoke-curers, an invention of recent origin, named the *Archimedean screw-ventilator*, deserves a place. It consists, as its name implies, of wine-vanes attached to the extremity of a revolving screw. When the wind strikes these vanes, it produces a rapid revolution of the screw, which is thus supposed to *wind up* the smoke or vitiated air from below. Perhaps it serves the proposed end; but whether the positive advantage thus gained is not lost by the obstruction of such apparatus to the free passage of smoke in calm weather, is a point in my estimation, more than questionable. For the relief of such chimneys as only smoke in windy weather, perhaps, this and other forms of external apparatus are best adapted. Another invention of equal merit, is a chimney-cap of metal, externally grooved in a series of spiral curves up the pipe, which end in a kind of mouth-piece, from whence the smoke issues. The wind, when impelled against this apparatus, is supposed to take somewhat of the direction of the spiral grooves, and thus to form an upward current to assist the emission of the smoke." One of the most recent of this class of inventions is *Day's wind-guard*, which consists of an octagonal metallic chimney-cap, having four slits in it, which are protected by projecting pieces or slips of metal. When a current of air strikes in any direction against the cap, it reflects or turns the air in such a manner, as immediately to produce a draught up the pipe. "In casting one's eye

down the long streets of the smoky city, in taking a survey of the roofs and their tormented chimneys, the infinity of other contrivances is so great, that it is scarcely a poetical hyperbole to say our pen starts back from it. Here is patent upon patent, scheme after scheme, each doing its best, no doubt, to obtain the mastery over that simple thing—smoke; and each with a degree of success of a very hopeless amount. There appears to me something intensely ludicrous in these struggles against what seems to be an absurd, but an invincible foe; the very element of whose success against us lies in our not strangling him in his birth. Many obstacles are in the way, no doubt; there are obstacles in the way of every good; but I have little doubt, that had the perverted ingenuity which has mis-spent itself upon the chimney-pots been directed to the fire-place, we might have now had a different tale to tell. The smoke nuisance is laughed at as a minor evil, by a great practical people like ourselves, who heroically make up our minds to put up with it; but when it is considered as an item in the comfort, cleauliness, and health of a whole nation, it assumes, or should assume, a different position.”

We do not by any means affirm that the above contrivances are always effectual in the cure of smoky chimneys; for it is easy to imagine cases where chimneys will, or rather must smoke, in spite of the whole host of caps, cowls, and vanes. For example, when a commanding eminence is farther from the wind than the chimney commanded, the wind would, as it were, be dammed up between the house and the eminence, and force its way down the chimneys, in whatever position the turn-cap or other contrivance might be situated. Dr. FRANKLIN mentions a city in which many houses were tormented with smoky chimneys by this operation; for their kitchens being built behind, and connected by a passage with the houses, the tops of the kitchen chimneys were thus lower than the tops of the houses; and thus, when the wind blew against the backs of the houses, the

whole side of a street formed a dam and the obstructed wind was forced down the kitchen chimneys, and passed along the passages into the houses, and so into the street. This was especially the case when the kitchen fires were burning badly. In summer, the annoyance assumed a different form, for the smoke was wafted from the kitchen chimneys into the chambers of the upper rooms.

Chimneys, which otherwise draw well, will often smoke from the improper situation of a door. Thus, when the door and the chimney are on the same side of the room, and the door, being in the corner, is made to open against the wall, as is usually done, to have it more out of the way, it follows that, when the door is partially opened, a current of air rushes in and passes along the wall into and across the opening of the fire-place, and whisks the smoke into the room. This happens more frequently when the door is being shut, for then the force of the current is increased, and persons sitting near the fire feel all the inconveniences both of the draught and the smoke. A remedy may be found by an intervening screen, projecting from the wall and passing round a great part of the fire-place; or, still better, by shifting the hinges of the door, so as to throw the air along the other wall.

A room with no fire in it is sometimes filled with smoke from the funnel of another room, in which a fire is burning. This arises from changes in density of the air in the cold funnel, from changes in temperature by day and by night, as well as from changes in the direction of the wind. It is found that when the temperature of the outer air and of that in the funnels is nearly equal, the air begins to ascend the funnels as the cool of the evening comes on, and this current will continue till nine or ten o'clock next morning; then, as the heat of the day approaches, it sets downwards, and continues to do so till evening; it then changes again, and continues to go upwards during the night. Now, when the smoke from the tops of neighboring funnels passes over

the tops of funnels which are drawing downwards, the smoke is also drawn down, and descends with the air into the chamber. The remedy proposed by Dr. FRANKLIN, was to contract the opening of the chimney to about two feet between the jambs, and to bring the breast down to about three feet of the hearth. An iron frame is then placed just under the breast, and extending to the back of the chimney, so that a plate of iron may slide horizontally backwards and forwards in the grooves on each side of the frame; this plate, when thrust quite in, fills up the whole space, and shuts up the chimney entirely, when there is no fire. But when there is a fire, it can be drawn out, so as to leave between its further edge and the back, a space of about two inches, which is sufficient for the smoke to pass; and so large a part of the funnel being stopped by the rest of the plate, the passage of warm air out of the room, up the chimney, is in great measure prevented, as is also the cold air from crevices to supply its place. The effect is seen in three ways: 1. When the fire burns briskly in cold weather, the howling or whisking of the wind, as it enters the room through the crevices when the chimney is open, ceases as soon as the plate is slid into its proper distance. 2. Opening the door of the room about half an inch, and holding the hand against the opening near the top of the door, you feel the cold air coming in against your hand, but weakly, if the plate be in. Let another person draw it out, so as to let the air of the room go up the chimney with its usual freedom in open chimneys, and you immediately feel the cold air rushing in strongly. 3. If something be set against the door, just sufficient when the plate is in to keep the door nearly shut, by resisting the pressure of the air that would force it open, then, when the plate is drawn out, the door will be forced open by the increased pressure of the outward cold air endeavoring to get in, to supply the place of the warm air that now passes out of the room to go up the chimney. "In our common open chimneys," says the

Doctor, "half of the fuel is wasted, and its effect lost; the air it has warmed being immediately drawn off."

The form of the chimney-pot has also an influence on the free passage of the smoke. Many of those fancy chimney-pots ornamented, singly or clustered together, will cause the chimneys to smoke in strong winds; the ornaments serving as points of resistance to the wind, after reflecting it down the chimney; and the clustered arrangement presenting a broad resisting surface, so that the wind, in blowing against them, rises up along the surface, and blows strongly over the mouths of the pots, so that the smoke cannot force its way through the blast. In Venice, the top of the flue is rounded into the true form of a funnel, and this is often found to answer the purpose; but, at present, we do not know of any remedy except a turn-cap, or one of the many elegant contrivances which give such wonderful variety to the sky-line of most of our houses and public buildings.

Cases of smoky chimneys may arise, which may puzzle the science of the most accomplished smoke-doctor. We borrow two such cases from FRANKLIN. "I once lodged," he says, "in a house in London, which, in a little room, had a single chimney and funnel. The opening was very small, yet it did not keep in the smoke, and all attempts to have a fire in this room were fruitless. I could not imagine the reason; till at length, observing that the chamber over it, which had no fire-place in it, was always filled with smoke when a fire was kindled below, and that the smoke came through the cracks and crevices of the wainscoat. I had the wainscoat taken down, and discovered that the funnel which went up behind it, had a crack many feet in length, and wide enough to admit my arm; a breach very dangerous with regard to fire, and occasioned, probably, by an apparent irregular settling of one side of the house. The air entering this breach freely, destroyed the drawing-force of the funnel. The remedy would have been,

filling up the breach, or rather rebuilding the funnel ; but the landlord rather chose to stop up the chimney."

The second case occurred at the house of a friend near London. "His best room had a chimney, in which he told me he never could have a fire, for all the smoke came out into the room. I flattered myself that I could easily find the cause, and prescribe the cure. I opened the door, and perceived it was not want of air. I made a temporary contraction of the opening of the chimney, and found that it was not its being too large that caused the smoke to issue. I went and looked up at the top of the chimney; its funnel was joined in the same stack with others, some of them shorter, that drew very well, and I saw nothing to prevent its doing the same. In fine, after every other examination I could think of, I was obliged to own the insufficiency of my skill. But my friend, who made no pretension to such kind of knowledge, afterwards discovered the cause himself. He got to the top of the funnel by a ladder, and looking down, found it filled with twigs and straw cemented by earth, and lined with feathers. It seems, the house, after being built, had stood empty some years before he occupied it; and he concluded that some large birds had taken the advantage of its retired situation to make their nests there. The rubbish, considerable in quantity, being removed, and the funnel cleared, the chimney drew well, and gave satisfaction."

It has been remarked, that chimneys situated in the north wall of a house, do not draw so well as those in a south wall; because when cooled by north winds, they are apt to draw downwards. Hence, chimneys enclosed in the body of a house, are more favorably situated than those in exposed walls. Chimneys in stacks often draw better than separate funnels, because those that have constant fires in them warm those in which there are none.

We have devoted a considerable space to this subject, because we think the reader has a right to expect, in a

practical book of this kind, tolerably full information on a subject in which all are interested; and the above cases seem to include most of the causes of smoky chimneys and their remedies. The open fire-place is so intimately connected with our ideas of domestic comfort, that it can never be expected, while coals are plentiful, that a more economical method of warming our rooms will become very common. It is, therefore, the duty of scientific men, to make the open fire-place as comfortable as it certainly is wholesome, and if a better method of supplying air to the fire than the present chance-arrangement were adopted; if caliducts were led round the fire, so as to discharge warm air into distant parts of the room, and even over the house; if the various parts of the fire-place were of the proper shape and dimensions, there seems to be no good reason against retaining our cherished open fire, and converting it from a troublesome, uncertain, smoky, and expensive companion, into a source of health, pleasure, and economy.

One of the most intelligent advocates (Dr. ARNOTT) in the cause of the CLOSE-STOVE *versus* the OPEN FIRE-PLACE, has preferred a very serious bill of indictment against the defendant. It consists of no less than eleven counts, of which the following is a summary :

I. *Waste of fuel*.—Of the whole heat produced from the fuel used, about seven-eighths ascend the chimney and are wasted. The loss of heat is, first, more than half, which is in the smoke as it issues from the burning mass. Secondly, that carried off by the current of the warmed air of the room, which is constantly entering the chimney between the fire and the mantel-piece, and mixing with the smoke. This is estimated at nearly two-eighths. Thirdly, the soot, or visible part of the smoke, is unburned fuel; and if more than half of the heat produced be in the smoke, and nearly a fourth of it in the warm air from the room, which escapes with the smoke, and if about an eighth of the combustible pass away unburned, there is a loss of at least seven-eighths



of the whole. Count RUMFORD estimated the loss at fourteen-fifteenths. These estimates must of course be supposed to refer to the open fire-place with square jambs.

II. *Unequal heating at different distances from the fire.*—

As the intensity of radiant heat is only one-fourth as great at a double distance, and so on, its effect being inversely as the square of the distance, the walls of the room are scarcely heated, and therefore reflect no heat to persons round the fire. There is usually one circular line around the fire in which persons must sit to be comfortable; and within this line they are too hot, and beyond it too cold.

III. *Cold draughts from doors and windows*

IV. *Cold foot-bath.*—The fresh-entering air, being colder than the general mass already in the room, occupies the bottom of the apartment, and forms a dangerous cold air-bath for the feet of the inmates, so that they must keep their feet raised out of it by foot-stools, or wear warmer clothing. We see how anxious cats are to get out of this cold air-bath by occupying the seats of chairs, &c., instead of the carpet.

V. *Bad ventilation.*—The heated respired air ascends to the ceiling, and getting cool, descends, and is breathed over again; or, if the fire be not sufficiently supplied with air from the door and windows, it will come from other quarters, and bring in foul air from drains, &c.

VI. *Smoke and dust.*

VII. *Loss of time* in lighting the fires in the morning, and again during the day, if neglected and allowed to go out.

VIII. *Danger to property.*

IX. *Danger to the person.*—Children get burnt, and the dresses of ladies sometimes take fire by a sudden draught from the door, or coming too near the fire.

X. *Expense of attendance.*—It is contended that servants have more work to do in houses with open fires, than where stoves are kept.

XI. *Necessity of siceeping-boys, when bituminous coal is used*

This is certainly a formidable indictment, but after the details given in the last chapter, it is not necessary to enter upon any further defence. There is no doubt that, upon some of the counts, the defendant must be found guilty; but it will be seen, in the present chapter, that the plaintiff does not come into court with clean hands, for there are many objections to the close stove, from which the open grate is entirely free. These will be stated as we proceed.

The close stove is used chiefly in those countries where fuel is scarce. One of the simplest forms is the *Dutch* stove which is a cylinder, standing upright. The fuel rests on the bars of a grate, near the bottom, and the air enters below the grate. The pipe enters the side of the cylinder, near the top. The fuel is introduced by a door on the side above the grate, which door is closed while the stove is in action, and as this is the only opening in the stove above the fuel, no air can reach the chimney, except that which has passed through the fire, thus saving the waste of warm air, which, in open fires, passes between the fire and the mantel-piece. The heating effect of this stove is due to the whole surface of the stove, and its flue, receiving the direct heat of combustion, as well as much of the heat of the products of combustion, as they escape into the chimney; and, if the flue be made sufficiently long, so as to expose a large surface in the room, nearly the whole of the heat may be applied to use, without draughts, or smoke, or dust. These are the good qualities of the Dutch stove; now for its bad ones. The heated iron surface acts upon the air in contact with it, so as to impair its purity and fitness for respiration. "The air," says Dr. ARNOTT, "acquires a burnt and often sulphurous smell, in part, no doubt, because dust, which it often carries, is burned, and in part, because there is a peculiar action of the iron upon the air. It becomes very dry, too, like that of an African simoom, shrivelling everything which it touches; and it acquires probably some new electrical pro-

perties. These changes combined make it so offensive, that persons, unaccustomed to it, cannot bear it. Many forms have been proposed, some of them gracefully designed, with transparent talc doors, and other attractions; and they have been tried in rooms, public offices, passages, halls, &c., but have been afterwards very generally abandoned. Persons breathing the air heated by them, are often affected by headaches, giddiness, stupor, loss of appetite, ophthalmia, &c. A north-east wind, which distresses many people, bringing asthmas, croups, &c., and which withers vegetation, is peculiar chiefly in being dry." This stove is much used by laundresses and others for drying, and in this application of it, the Doctor admits, it is good and economical. The ornamental varieties of it are also furnished with vases and other receptacles for water, which, by its evaporation, greatly mitigates the evils complained of; but it must be admitted, that the list of objections brought against the Dutch stove forms as formidable a bill of indictment as that preferred against the open fire. Another objection, not noticed in the above quotation, arises from the overheating of the flue. It has often been known to get red-hot, and has thus led to serious conflagrations.

A stove is common in the United States, which consists of a square, close iron box, with a vessel of water upon it, to give moisture to the air. It has a plate projecting under the door; the wood fuel is burned within, and the flame passes along to the chimney, around an inner box, which is the cooking oven of the family, opening by a door in the side of the stove. The fuel is introduced by a large door, in which there is a smaller one, which, as well as the larger, is usually kept shut, because a sufficient supply of air enters by the joinings around; but in cold weather, the small door is opened to increase the combustion. The stove has iron legs.

In Russia, Prussia, and the North of Europe generally, the stove is a very important article of domestic furniture,

in which the largest possible amount of heating effect is obtained from the smallest possible quantity of fuel. In the construction of these stoves, the following points are kept in view: To maintain in the fire-place the high temperature necessary for the perfect combustion of the fuel, by surrounding it with such substances as are bad conductors of heat, such as fire-stone or bricks; to have the means of regulating the quantity of air admitted to the fuel, by valves in the doors which enclose the ash-pit and fire-chamber, and by accurate fitting of the doors and valves themselves. Thirdly, to bring all the gaseous productions of combustion, as they escape from the fuel, into contact with the largest possible area of slowly-conducting surface, so as to maintain it at an equal temperature; and, lastly, to make the smoke enter the chimney with the smallest velocity, or lowest temperature, that is practically consistent with the first condition. In no case should this temperature exceed  $150^{\circ}$ , nor should the metallic surface ever be raised higher than  $100^{\circ}$ , nor the stream of air issuing from it exceed  $70^{\circ}$ . In every case, the combustion is regulated by limiting the supply of air; and if the heating surface be small, the fire is reduced so as to produce no more heat than can be carried off by the radiation and conduction of such heating surface.

The author of "*A Residence on the Shores of the Baltic*," 1841, refers to these stoves in the following terms:—"Within these great houses, not a breath of cold is experienced. The rooms are heated by stoves, frequently ornamental rather than otherwise; being built in tower-like shapes, story over story, of pure white porcelain, in various graceful architectural mouldings; sometimes surmounted with classic figures of great beauty, and opening with brass doors, kept as bright as if they were of gold. In houses of less display, these stoves are merely a projection in the wall, colored and corniced in the same style of the apartment. In adjoining rooms they are generally placed back to back, so that the same fire suffices for both. These

are heated but once in the twenty-four hours, by an old caliban, whose business during the winter it is to do little else. Each stove will hold a heavy armful of billet, which blazes, snaps, and cracks most merrily; and when the ashes have been carefully turned and raked with what is termed an *ofengabel*, or stove-fork, so that no unburnt morsel remains, the chimney aperture is closed over the glowing embers, the brass doors firmly shut, and in about six hours after this, the stove is at the hottest—indeed, it never cools.”

The useful effect of this stove depends very much on retaining in the room the air already heated by it. A small, open fire in the same room will actually diminish the heating effect of the stove, and even draw the warm air from adjoining apartments. In the houses of English merchants at St. Petersburg, open fires are sometimes introduced into rooms with stoves; and the consequence is, that it is found necessary to light the stoves twice a day, and yet the houses are cooler than those of the Russians, who light them only once. To our notions, however, a cool in-door atmosphere is preferable to a nauseous stagnant one, such as the Russians and Germans are accustomed to breathe throughout the winter; and even in summer, they are very averse to an open window. The temperature of the winter apartments is kept nearly always at 65°, and as every part of the room is equally warm, the inmates have no occasion to crowd round the stove as we do round the fire. “But I can testify,” says Dr. Buxton, “that in German rooms there is a closeness of feeling, to a person accustomed to free air, which is unpleasant, if not unwholesome—no change of air—the windows closed as tight as can be, and the door fits as exactly as the carpenter can make it. The stove is air-tight with regard to the room, and there is nothing to occasion a current like our open fires. The apartments of the sick almost invariably smell disagreeably. I do not, however, recollect seeing a single ventilator in Germany; but I have repeatedly seen double windows.” As ventilation can only be

procured at the expense of heat, the people prefer retaining the foul air to expending an extra portion of fuel. In the houses of the poorer classes in Russia, where the windows are single, and a number of persons occupy a small stove-heated room, a thick icy crust forms on the inside of the windows during frosty weather, arising from the condensation of the breath, perspiration, and the aqueous fumes of candles, and of the stove, &c. When a thaw comes on, this icy crust is converted into water, and a deleterious principle is disengaged, which produces effects similar to those arising from the fumes of charcoal. Persons so affected are immediately carried into the open air, and placed on the snow, with very little clothing; the temples and the region of the stomach are well rubbed with snow, and cold water is poured down their throats, and the friction is continued until the livid hue of the skin disappears, and the natural color is restored. The Chinese are wiser in this respect than the Russians, for, although their rooms in winter be are hot and as crowded, they have two openings at the top of each window, which are never allowed to be closed, and through these ventilation is carried on.

The stove last described belongs rather to that variety called the *Swedish stove*, than to the *Russian* or *German*. In the Russian or German stove, the smoke, after rising from the fuel, recedes into the flue, and becomes cooled by contact with the walls of the circulating chambers, and the heat is by this means retained in the apartment which would otherwise have escaped combined with the vapor. In the Swedish stove, the circumvolutions of the smoke are exposed to a vivid heat, so that every particle of soot undergoes a second combustion in the circulating channels. Some of the Swedish stoves have from four to nine channels for the circulation of the smoke; some are contrived to receive one or more boilers, and others to act as ovens; and they all greatly economize the fuel. According to MORVEAU, the quantity of wood which is consumed in twenty-three days

in an open fire, with less effect, will last sixty-three days in a stove.

In erecting the ponderous German stoves, it is necessary to arrange the various pieces of clay, or porcelain, so that no part should crack or give way, and thus admit the smoke or carbonic acid vapor into the room. When the parts are put together with cement, or held by iron cramps, a leakage commonly occurs at the joinings, where different pieces of clay are differently heated, and perhaps were of a different baking when made; hence, by expanding unequally and working on each other, one of them must give way. But instead of making the joints close and using any cement, the best method is to make each upper piece stand in a groove formed in the piece below it, and then to sprinkle a little powdered chalk or clay over it, which will effectually prevent the passage of any air, and, at the same time, allow space for any expansion or contraction at the joint.

Some valuable experiments by Mr. BULL are quoted by Mr. BERNAM, to show the effect of ascending and descending flues in the Russian and Swedish stoves, and of elbows or bends in the flue of the common Dutch stove. From these experiments, it appears that the same length of pipe is much more efficacious in imparting heat to a room when it has elbows than when it is straight; that a descending current may be somewhat more efficacious than an ascending one, but is about equal with a horizontal one; a horizontal pipe, with the same number of elbows, is more efficacious in imparting heat, than when placed vertically for an ascending and descending current. The cause of the increased effect is supposed to arise from the shape of the pipe forcing the heated air to make abrupt turns; in doing which, it impinges against the elbows with sufficient force to invert its internal arrangement, by which a new stratum of hot air from the interior of the current is brought more frequently in contact with the sides of the pipe, and par-

ticularly with the lower half of the horizontal pipe, which, from various causes, gives out very little heat to the room, without the aid of elbow-joints. But the advantage gained by increasing the length of pipe and number of joints, has a limit very far short of that which is found to be necessary to impart all, or the greatest part, of the heat generated to the air of the room. Only five parts of heat in 100 were lost by using  $13\frac{1}{2}$  feet of pipe, consisting of nine elbow-joints; whereas, eight additional elbow-joints, and  $16\frac{1}{2}$  feet additional of straight pipe—in all  $28\frac{1}{2}$  feet of pipe—were required to save these five parts, and prevent their flowing into the chimney. By diminishing the diameter of the pipe, the heating effect is increased, partly from the retardation of the current, and partly from the small pipe exposing a greater surface to the air with the same quantity of smoke than a pipe of larger diameter.

An excellent stove with a descending current was constructed by Dr. FRANKLIN, for his own use.

It was shaped like a pear or vase, and stood on its small end. There was an opening in the top to put in the fuel. About two-thirds the way down was a grate. The lower end of the stove opened into horizontal flues, which communicated with the chimney. The vase and flues are contained in a niche formed by closing up the fire-place, and there is no communication between the room and the flue, except through the opening in the lid or cover. The fire is first lighted between 8 o'clock in the morning and 8 o'clock in the evening, when there is usually a draught *up* the chimney, as already explained; but the direction of the draught had better be ascertained by holding a flame over the air-hole at the top of the vase. If the flame be drawn strongly down, the fire may be lighted by first putting in a little charcoal on the grate; then lay some small sticks on the charcoal and some paper on the sticks; set light to the paper and shut down the lid; the air will pass down through the air-hole, and blowing the flame of the paper through the



sticks, kindle them, and they, in their turn, will kindle the charcoal. The flame and hot vapor descending through the grating, passes into the chamber and through the second grating in its bottom into the ash-pit. The hot current will then be divided—one portion turning to the left, and passing into horizontal channels and entering the vertical flue, will be conducted into the chimney; the other portion will make a similar circuit on the left, and entering another flue, will in like manner pass into the chimney. The surfaces of the vase and air-box, and the part of the horizontal channels exposed to the room, are heated by these circumvolutions of the vapor, and the air warmed by contact with them, spreads into the room. The large pieces of coal that fall through the grating on the vase, are caught by the second grating, and the ashes fall through it into the ash-pit box. The success of this excellent contrivance depends, of course, upon maintaining an upward, steady draught in the chimney flue, so that the ash-pit drawer and a door in the chamber, to withdraw the cinders, must be made air-tight. In order to determine an upward current on lighting the fire, a small door may be made in the side of the flue, and a piece of lighted paper inserted.

A combination of the stove and the grate, combining the heating effect of the stove with the cheerful appearance and ventilating properties of the open fire, is known under the name of the *stove-grate*, or *Chapelle*; the latter name being derived from its resemblance to the chapels or oratories of the great churches.

Professor ROBISON describes it as the most perfect method of warming an apartment. Its construction is as follows: In the great chimney-piece is set a smaller one, of a size no larger than is sufficient for holding the fuel. The sides and back are of cast iron, and are kept at a small distance from the sides and back of the main chimney-piece, and continued down to the hearth; so that the ash-pit is also separate. The pipe or chimney of the stove-grate is

carried up behind the ornaments of the mantel-piece, until it rises above the mantel-piece of the main chimney-piece, and is fitted with a register, or damper-plate, turning round a transverse axis. The best form of this register is that of an ordinary fire-place, with its axis or joint close at the front, so that when open or turned up, the burnt air and smoke, striking it obliquely, are directed with certainty into the vent, without any risk of reverberating and coming out into the room. All the rest of the vent is shut up by iron plates or brick-work out of sight.

The fuel being in immediate contact with the back and sides of the grate, raises them to a great heat, and they heat the air contiguous to them. This heated air cannot get up the vent, because the passage above these spaces is shut up. It therefore comes out into the room ; some of it goes into the real fire-place, and is carried up the vent, and the rest rises to the ceiling, and is diffused over the room. The heating effect of this stove is remarkable. Less than a quarter of the fuel consumed in an ordinary fire-place is sufficient, and this, with the same cheerful, blazing hearth, and the salutary renewal of the air. Indeed, it often requires attention to keep the room cool. The heat communicated to those parts of the apparatus which are in contact with the fuel, is needlessly great, so that it has been found an improvement to line this part with thick plates of cast iron, or with tiles of fire-clay. These being bad conductors, moderate the heat communicated to the air. If the heat be still found too great, it may be brought under perfect management, by opening passages in the vent for the spaces on each side, so that the air heated by the sides of the stove-grate may ascend directly into the flue, instead of escaping into the room. These passages may be closed by valves, or trap-doors, moved by rods concealed behind the ornaments of the fire-place.

The stove-grate is under complete control as to temperature. A cheerful fire may be insured within five minutes,

simply by hanging a plate of iron in front so as to reach down as low as the grate; and when the fire is by its means blown up, the plate may be taken down and sent out of the room, or set up behind the grate out of sight. If, on the other hand, the room be found inconveniently warm, the temperature may be cooled down within a quarter of an hour, by opening the side-passages to any extent, for the escape of the hot air. In this arrangement the ash-pit is enclosed, because the light ashes, not finding a ready passage up the chimney, are apt to escape into the room with the heated air.

Few contrivances for warming apartments have excited more attention and discussion of late years, than Dr. ARNOTT's stove. The principle of this invention consists, in allowing the fuel to burn very slowly, the admission of air for combustion being regulated by a peculiar contrivance. There are various forms and modifications of this stove, but the principle is the same in all. The stove consists of a square or cylindrical box of iron, lined with fire-clay, with a grating near the bottom for the fuel, or the fuel may be contained in a small fire-box within the stove. Sometimes the fuel is burned within a hollow cylinder of fire-clay, and then the stove is not lined with that material. There is an ash-pit below for the ashes, and the products of combustion are carried off by a vent. The chief feature of this stove is, the contrivance by which the air is admitted to the fuel. When the stove-door or ash-pit door is open, the combustion is vivid; but when these are perfectly tight, as they ought to be, then the air is admitted by a regulator.

A mercurial gauge was used to regulate the draught of the stove. A glass tube was used, partially filled with mercury; on the top of the mercury was placed a float, from which proceeded an upright rod, kept steady by passing through a support; from this upright rod descended another wire, terminated by an ordinary plate-valve in the tube of the stove. When the heat is great, the expansion

of the mercury raises the float, which raises the rods and the plate-valve, bringing it in nearer contact with the mouth of the vent by which less air is admitted to the stove. When the room is cold, the operation is exactly the reverse—opening instead of closing the valve. There were a number of alterations or improvements on this arrangement. In some, the shape of the tube was such, that the expansion of the air in the tube caused the mercury to rise and fall.

These arrangements are liable to the objections already stated, viz: that the air of the room, though sufficiently heated, is nevertheless stagnant. Another objection is that which is considered its chief merit, viz: the slow combustion of the fuel, whereby carbonic oxide is generated, and, from the small draught of the chimney, is liable to escape in the room.

The method of warming buildings by STEAM, depends on the rapid condensation of steam into water when admitted into any vessel which is not so hot as itself. At the moment of condensation, the latent heat of the steam is given out to the vessel containing it, and this diffuses the heat into the surrounding space.

The first practical application of this principle was made by JAMES WATT, in the winter of 1784–5, who fitted up an apparatus for warming his study. The room was 18 feet long, 14 feet wide, and  $8\frac{1}{2}$  feet high. The apparatus consisted of a box, or heater, made of two side-plates of tinned iron, about  $3\frac{1}{2}$  feet long by  $2\frac{1}{2}$  feet wide, separated about an inch by stays, and jointed round the edges by tin plate. This heater was placed on its edge, near the floor of the room. It was furnished with a cock to let out the air, and was supplied with steam by a pipe from a boiler, entering at its lower edge; and by this pipe, the condensed water also returned to the boiler. The heating effect of this apparatus was not so great as was expected, in consequence, perhaps,

of the bright metallic surfaces of the box not being favorable to radiation.

In 1791, Mr. HOYLE, of Halifax, took out a patent in England for heating by steam pipes, and his method seems to have been the foundation for subsequent attempts. The steam was at once conveyed from the boiler, by a pipe, to the highest elevation of the building required to be heated; and, from that point, by a gentle declivity, the condensed water flowed into the supply-cistern of the boiler. The effect of the pipes (which were of copper) was too small, and as the apparatus was constantly getting out of order, it was pronounced a failure.

In 1793, Mr. GREEN took out a patent in England for a different method, which consisted in enclosing a hollow vessel, or worm-pipe, in a boiler containing hot water or steam. The air, on its way to the room to be warmed, was made to pass through this worm, and was thus heated to an agreeable temperature. By another method, pipes from a steam-boiler were enclosed in other pipes, and, in the interval between them, the air was heated on its passage to the room. This apparatus was erected in a mansion on Wimbledon Common. The encased pipe was fixed along the ceiling of the basement floor, with an inclination of two inches in 68 feet. The inner steam-pipe was three inches in diameter, the outer pipe nine inches, and both of copper. The lower end of the casing-pipe was left open for the cold air to enter; the other end was joined to a pipe four inches in diameter, with three horizontal elbows, that rose about twelve inches, where it opened into the first suite of rooms that were to be heated. It was supposed that the air would enter at one end in great quantity, and flow out through the small pipe at the other end into the rooms; the effect, however, was so feeble, that no useful heating was produced.

About this time, steam was introduced into hot-houses, not by circulating in pipes, but by being discharged into the body of the hot-house, the effect of which was to raise its

temperature and moisten the air to such a degree, that the plants grew rapidly and luxuriantly. It is also said to have had the effect of destroying insects.

In the winter of 1795-6, Mr. BOULTON erected a steam heating apparatus in the library of his friend, Dr. WITHERING, "which, in point of heating, answered perfectly; but the pipes being made of copper, and soft-soldered in some places, the smell of the solder was rather unpleasant to the Doctor, who was then in an infirm state of health with diseased lungs. The apparatus was, in consequence, removed to Soho, where Mr. BOULTON proposed erecting it in his own house, in which he was making alterations about this time, and had it in view to heat every room in the house by steam. A boiler was put up for that purpose in one of the cellars, but some circumstance occurred to prevent his continuing the plan. The subject, however, underwent frequent discussions, and the different modes of effecting it were amply considered by Messrs. BOULTON and WATT, as was known to many of their friends—no secret having been made, of calculations of surface, or the modes of applying them."

About the end of the year 1799, Mr. LEE, of Manchester, under the direction of BOULTON and WATT, erected a heating apparatus of cast-iron pipes, which served also as supports to the floor. This answered perfectly, and was, in point of materials and construction, the earliest of its kind. Mr. LEE afterwards had his house heated by steam, and the staircase, hall, and passages, were warmed by the apparatus. It was placed in the underground story, and consisted of a vertical cast-iron cylinder, surrounded by a casing of brick-work, leaving a space of two and a half inches all round, and having openings below, to admit the air. This casing was surrounded, at the distance of three or four inches, by another wall, forming a sort of well. The colder and heavier air falling to the bottom of this well, entered by the holes into the space, where it came in contact with the cylinder, and, being heated, ascended.

The entrance of the steam into the cylinder was regulated by a valve, the air being allowed to escape by a stop-cock, while the steam was entering; the condensed water escaping by a pipe. The transmission of the heated air was regulated by a valve on the top of the brick-work. This apparatus was so effective, and heated the staircase to such a degree, that after it had been in operation a short time, it was necessary to suspend its action by closing the valve which admitted steam into the cylinder.

The method of heating buildings by steam has scarcely advanced since the time when MESSRS. BOULTON and WATT erected their apparatus for the purpose, and Mr. BUCHANAN wrote a practical treatise on the subject. The hot-water apparatus has, for the most part, superseded the steam apparatus, so that our details need not be very full.

In establishments where a steam-engine is in daily use, the steam-pipes may be supplied from the engine-boiler, its dimensions being enlarged at the rate of one cubic foot for every 2,000 cubic feet of space, to be heated to the temperature of  $70^{\circ}$  or  $80^{\circ}$ . A boiler adapted to an engine of one-horse power, is sufficient for heating 50,000 cubic feet of space. Hence an apparatus specially erected for the purpose need not be of very large size, nor is the quantity of fuel consumed great. If the fire under a small boiler be carefully managed, 14lbs. of Newcastle coal will convert one cubic foot of water at  $50^{\circ}$ , into 1,800 cubic feet of steam at  $216^{\circ}$ ; and only 12lbs. of coal are required to convert the same quantity of water into steam at  $212^{\circ}$ . The shape of the boiler, and the method of setting it, must also be considered, and the furnace must be arranged so as to admit no more air than is required to support the combustion. The hot air must also be kept in contact with the sides of the boiler, until as much of the heat as possible be abstracted from it. In such an arrangement, according to Dr. ARNOTT, nearly half of all the heat produced in the combustion is applied to use.

In estimating the extent of surface of steam-pipe required to raise the rooms to the proper temperature, it is necessary to consider how the heat is expended. This is done in three ways: 1. Through the thin glass of the windows. 2. More slowly through the walls, floors and ceiling; and 3. In combination with the air which escapes at the joinings of the windows and doors, or through openings expressly made for the purpose of ventilation. The amount of heat lost in this way has been variously estimated by different writers, but Dr. ARNOTT states it thus; That in a winter day, with the external temperature at  $10^{\circ}$  below freezing, to maintain in an ordinary apartment the agreeable and healthful temperature of  $60^{\circ}$ , there must be a surface of steam-pipe, or other steam-vessel heated to  $200^{\circ}$  (which is the average surface-temperature of vessels filled with steam of  $212^{\circ}$ ), about one foot square for every six feet of single glass window of usual thickness; as much for every 120 feet of wall, roof and ceiling of ordinary material and thickness; and as much for every six cubic feet of hot air escaping per minute as ventilation, and replaced by cold air. A window, with the usual accuracy of fitting, allows about eight feet of air to pass by it in a minute, and there should be for ventilation, at least three feet of air per minute for each person in the room. According to this view, the quantity of steam-pipe, or vessel, needed, under the temperature supposed, for a room 16 feet square by 12 feet high, with two windows, each 7 feet by 3, and with ventilation, by them, or otherwise, at the rate of sixteen cubic feet per minute, would be:

	FEET.
For 42 square feet of glass (requiring 1 foot for 6) . . . . .	7
“ 1,238 feet of wall, floor and ceiling (requiring 1 foot for 120) . . .	$10\frac{1}{2}$
“ 16 feet per minute for ventilation, (requiring 1 foot for 6) . . .	$2\frac{1}{2}$
<hr/>	
Total of heating surface required . . . . .	20

Which is 20 feet of pipe, 4 inches in diameter, or any other vessel having the same extent of surface,—as a box two feet



high, with square top and bottom of about eighteen inches. It may be noticed, that nearly the same quantity of heated surface would suffice for a larger room, provided the quantity of window-glass, and of the ventilation, were not greater; for the extent of wall, owing to its slow-conducting quality, produces comparatively little effect.

The same excellent authority also supplies the following illustrations: A heated surface, as of iron, glass, &c., at temperatures likely to be met with in rooms, if exposed to colder air, gives out heat with rapidity, nearly proportioned to the excess of its temperature above that of the air around it, less than half the heat being given out by radiation, and more than half by contact of the air. Thus, if the external surface of an iron pipe, heated by steam, be  $200^{\circ}$ , while the air of the room to be warmed by it, is at  $60^{\circ}$ , showing an excess of temperature in the pipe of  $140^{\circ}$ , such pipe will give out nearly seven times as much heat in a minute as when its temperature falls to  $80^{\circ}$ , because the excess is reduced to  $20^{\circ}$ , or  $\frac{1}{7}$  of what it was. Supposing window glass to cool at the same rate as iron plate, one foot of the steam pipe would give out as much heat as would be dissipated from the room into the external air by about five feet of window, the outer surface of which were  $30^{\circ}$  warmer than that air. But as glass both conducts and radiates heat about  $\frac{1}{7}$  slower than iron, the external surface of the glass of a window of a room, heated to  $60^{\circ}$ , would, in an atmosphere of  $22^{\circ}$ , be under  $50^{\circ}$ , leaving an excess of less than  $30^{\circ}$ ; and about six feet of glass would be required to dissipate the heat given off by one foot of the steam pipe. In double windows, whether of two sashes, or of double panes, only half an inch apart in the same sash, the loss of heat is only about one-fourth of what it is through a single window. It is also known that one foot of black or brown iron surface, the iron being of moderate thickness, with  $140^{\circ}$  excess of temperature, cools in one second of time 156 cubic inches of water, one degree. From this standard fact, and the law above given, a rough

calculation may be made for any other combination of time, surface, excess, and quantity. And it is to be recollected, that the quantity of heat which changes, in any degree, the temperature of a cubic foot of water, produces the same change on 2,850 cubic feet of atmospheric air.

The arrangement of the steam-pipes has next to be considered. A common method is that in which the pipe from the boiler rises at once to the upper story. From this pipe proceed horizontal branches, to each floor. Each branch is furnished with a stop-cock, by which means the steam can be turned on or off at pleasure, in any one of the three stories. The water arising from the condensation of the steam in each pipe, flows back into the boiler along the ascending pipe. But if it be not convenient to place the boiler below the level of the lowest floor, the condensed steam is received into a reservoir, from which it is pumped into the feeding-cistern. At the extremity of each horizontal branch, is a stop-cock, which is opened, when the steam is filling, to allow the air to blow off.

It is necessary to prevent the condensed water from accumulating in the pipes, otherwise it would be impossible to maintain them at a uniform temperature. Moreover, this water condenses the steam so rapidly, that a vacuum is formed within the boiler and pipes ; and should they not be firm enough to resist the external pressure of the atmosphere, the boiler may be crushed in, and the whole system deranged. By a special arrangement, the condensed water is collected at certain parts of the system, where it continues to give out heat after the steam has ceased to flow into the pipes. In such cases, stop-cocks may be employed, so arranged as to allow the water to be afterwards withdrawn from the pipes ; the same cocks also serve for letting the air out of the pipes when the steam is first admitted ; but when the water is returned into the boiler, the advantage of this supply of heat cannot be reserved ; and in these

cases, a self-acting apparatus is used for taking off the water of condensation.

The various methods of connecting the cast-iron pipes are by the flanch-joint, and the spigot and faucet, or socket joint. Mr. BUCHANAN gives minute directions for these, but he seems inclined to recommend the thimble-joint. Care must, of course, be taken in joining the pipes, to allow room for expansion. This is sometimes done in the thimble-joint, in which the adjoining ends of the pipes are turned true on the outside, and have a thimble, or short cylinder of wrought-iron, to enclose them, leaving only a small space for the current. A piece of tin, or inner thimble, is interposed, and made to fit well to the turned parts of the pipes, which, under the influence of heat or cold, work forwards or backwards, like a piston in a cylinder. In a range of pipes 120 feet in length, there was a motion from expansion of three-quarters of an inch; but the usual allowance for the expansion of cast-iron pipes, is one-eighth of an inch in 10 feet, or  $\frac{1}{80}$  of their length. Cast-iron heated from  $32^{\circ}$  to  $212^{\circ}$ , expands  $\frac{1}{80}$  of its length, which is nearly one and three-eighths of an inch in 100 feet. A similar expansion-joint applied to the spigot and faucet connection, answered very well. Lead cannot be substituted for tin or iron cement in joints, for, by frequent heating, it becomes permanently expanded, while the iron pipes always contracting in cooling, and the lead not participating in the contraction, the joints soon get loose. Count RUMFORD introduced an expansion-drum, of thin copper, between the extremities of two pipes, which in elongating, pressed the sides of the drum inwards, and in cooling drew them outwards. The pipes should not be connected with any part of the building, but be quite independent thereof; all the horizontal branches should be supported on rollers, and nothing done to interfere with the expansion of the different parts.

In private dwellings, where the appearance of the pipes is objectionable, they may be concealed behind perforated

mouldings, or skirtings or cornices; or the steam may be brought into ornamental vases dispersed about the room, each furnished with a small stop-cock, to allow the air to escape while the steam is entering.

The method of heating buildings by steam has long been superseded by hot water apparatus of various kinds; which, however, may be resolved into two distinct forms or modifications, dependant on the temperature of the water. In the *first* form of apparatus, the water is at or below the ordinary temperature of boiling. In this arrangement the pipes do not rise to any considerable height above the level of the boiler, so that the apparatus need not be of extraordinary strength. One pipe rises from the top of the boiler, and traverses the places to be warmed, and returns to terminate near the bottom of the boiler. Along this tube the heated water circulates, giving out its heat as it proceeds. The boiler may be open or closed. If open, the tube, when once filled with water, acts as a siphon, having an ascending current of hot water in the hotter leg, and a descending current of cooled water in the longer leg. If the boiler be closed, the siphon-action disappears, and the boiler with its tubes become as one vessel. In the *second* form of apparatus, the water is heated to  $350^{\circ}$  and upwards, and is, therefore, constantly seeking to burst out as steam, with a force of 70lbs. and upwards on the square inch, and can only be confined by very strong or high-pressure apparatus. The pipe is of iron, about an inch in diameter, made very thick. The length extends to 1,000 feet and upwards, and where much surface is required for giving out heat, the pipe is coiled up like a screw. A similar coil is also surrounded by the burning fuel, and serves the place of an oiler.

The heating of rooms by the circulation of hot water in pipes, seems to have occupied the attention of a few speculative individuals, long before the attempt was actually made. The first successful trial is assigned to Sir MARTIN TREB-WALD, a Swede, who resided for many years at Newcastle-

on-Tyne, and about the year 1716, described a method for warming a green-house by hot water. The water was boiled outside the building, and then conducted by a pipe into a chamber under the plants.

But the first successful attempt, on a large scale, was in France, in 1777, by M. BONNEMAIN, in an apparatus for hatching chickens, for the purpose of supplying the market of Paris. The water was heated in a boiler—ascended a feed-pipe, and ran through the heating-pipes which traversed the hatching-chamber, fore and aft.

These heating-pipes have a gradual slope towards the boiler, to which the water returns by the pipe, carried nearly to the bottom. In this way the water, cooled by being circulated through a long series of pipes, is being constantly returned to the lowest part of the boiler, where it receives a fresh amount of heat, and being thus rendered lighter, rises up the pipe, and descends the inclined planes of the pipes, losing a portion of its heat on the way, and at the same time increasing in density; the velocity of the current depending on the difference between the temperature of the water in the boiler, and that in the descending-pipe. At the highest point of the apparatus is a pipe, furnished with a stop-cock, for the escape of the air which the cold water holds in solution on entering the boiler. The water that rises along with it is received into the vessel.

The arrangements of this apparatus are excellent; they have been taken as a model in many subsequent methods, although the merits of the inventor have not always been acknowledged. Whatever be the arrangement adopted for warming buildings by this method, two considerations must be specially attended to, namely, sufficient strength to bear the hydrostatic pressure, and freedom of motion for currents of water, of varying temperatures, and consequently of varying densities. As fluids transmit their pressure equally in every direction, a column of water rising from a strong vessel to a certain height, may be made to burst the vessel

with enormous force. Thus, a tube whose sectional area is one inch, rising to the height of  $34\frac{1}{2}$  feet from the bottom of a vessel of water, will, if the tube be also full of water, exert a bursting pressure on every square inch of the inner surface of such vessel of one atmosphere, or 15 lbs. If the sectional area of the tube be increased, the pressure remains the same, because it is distributed over a larger surface of the vessel. If a boiler be 3 feet long, 2 feet wide, and 2 feet deep, with a pipe 28 feet high from the top of the boiler, when the apparatus is filled with water, there will be a pressure on the boiler of 66,816lbs., or very nearly 30 tons. This will show the necessity for great strength in the boiler, especially when it is considered that the effect of heat upon it is to diminish the cohesive force of its particles. But even supposing the apparatus were to burst, no danger would arise, because water, unlike steam, has but a very limited range of elasticity. The boiler just described would contain about 75 gallons of water, which, under a pressure of one atmosphere on the square inch would be compressed about one cubic inch; and if the apparatus were to burst, the expansion would only be one cubic inch, and the only effect of bursting, would be a cracking in some part of the boiler, occasioning a leakage of the water.

The circulation of water is brought about by the principle of convection already explained in the case of air. When heat is applied to a vessel containing water, the principle of conduction altogether fails, for water is so imperfect a conductor of heat, that if the fire be applied at the top, the water may be made to boil there without greatly affecting the temperature below. But when the fire is applied below, the particles in contact with the bottom of the boiler, being first affected by the heat, expand, and thus becoming specifically lighter than the surrounding particles, ascend, and other particles take their place, which in like manner becoming heated, ascend also; and the process goes on in this way until the whole contents of the boiler have received

an accession of temperature. If the process be continued long enough, the water will boil and pass off in steam; if the boiler be closed in on all sides, so as to prevent the escape of steam, it will burst with a fearful explosion. If a tube full of water rise from the top of the boiler in a vertical line to any required height, and then by a series of gentle curves descend, and enter near the bottom of the boiler, the process of heating is still the same. The particles of water first heated will rise, and, in doing so, distribute their heat to other particles, which will also rise; these, in their turn, will lose a portion of their heat to other particles, which rise in their turn; until at length an equilibrium is established. But as the source of heat is permanent, other particles are rapidly brought under its action, and, being heated, ascend. By continuing the process a short time, the particles in the vertical tube become heated, and, by their expansion, exert a pressure on the water contained in the lateral branches; this, together with the increasing levity of the water in the boiler, establishes a current, and the water from the branches begin to set in, in the direction of the boiler; the water in the lowest branch, where it enters the boiler, supplying colder and heavier particles every moment to take the place of the warmer and lighter particles which are being urged upwards along the vertical pipe.

Now, to ascertain the force with which the water returns to the boiler, we must know the specific gravities of the two columns of water, the ascending and the descending, and the difference between them will be the effective pressure, or motive power. This can be done by ascertaining the temperature of the water in the boiler, and in the descending pipe. When the difference amounts to only a few degrees, the difference in weight is very small, but quite sufficient, in a well-arranged apparatus, to maintain a constant circulation. For example, suppose an apparatus to be at work, in which the temperature in the descending pipe is  $170^{\circ}$ , and the

temperature of the water in the boiler, the height of which is 12 inches, is  $178^{\circ}$ . The difference in weight is 8.16 grains on each square inch of the section of the return-pipe.

Mr. Hood made an experiment by taking a boiler two feet high, containing 30 gallons of water, and letting two 4-inch pipes of one hundred yards length, running parallel, enter the boiler—one three inches from the top and the other three inches from the bottom—so connected at their farther end that the water could flow through and return freely, and found that there was 190 gallons, or 1,900lbs. of water, kept in motion by a force equal to one-third of an ounce.

The amount of motive power increases with the size of the pipe. The power being four times as great in a pipe of four inches in diameter as in one of two inches, as the former contains four times as much water as the latter; but as the resistance increases equally with the power, the actual working effect is the same in pipes of all sizes. The motive power is increased by allowing the water to cool before it returns to the boiler, or by increasing the height of the ascending and descending columns of water. By doubling the difference of temperature between the flow-pipe and the return-pipe, the same increase of power is obtained as by doubling the vertical height; and by tripling the difference in temperature, the same effect is produced as by tripling the vertical height. The difference in temperature may also be increased by increasing the quantity of pipe, or by diminishing its diameter, so as to expose a larger amount of surface, in proportion to the quantity of water contained in it, so as to allow it to part with more heat within a given time. But the method which must be principally depended on, when additional power is required to overcome any unusual obstruction, is to increase the height of the ascending column.

Another method of estimating the velocity of motion of the water of a hot-water apparatus, is to regard the two



portions of the system, as the lighter and heavier fluids in the two limbs of a barometrical aëriometer. This instrument is an inverted siphon, and its use is to ascertain, in a rough way, the specific gravities of immiscible fluids. If mercury be poured into one limb, and water into the other, and the stop-cock at the centre be turned, so as to establish a communication between them, it will be found that an inch of mercury, in one limb will balance thirteen-and-a-half inches of water, in the other limb; thus showing that the densities, or specific gravities, of the two fluids, are as thirteen-and-a-half to one. If oil be used instead of mercury, it will require ten inches of oil to balance nine inches of water. Or if equal bulks of oil and water be poured into the limbs of the siphon, and the stop-cock be then turned, the oil will be forced upwards with a velocity equal to that which a solid body would acquire in falling, by its own gravity, through a space equal to the additional height which the lighter body would occupy in the siphon. Now, as the relative weights of water and oil are as nine to ten, the oil in one limb will be forced upwards by the water with a velocity equal to that which a falling body (in this case, the water) would acquire in falling through one inch of space, and this velocity is equal to 138 feet per minute.

In estimating the velocity of motion of the water in a hot water apparatus, the same rule will apply. "If the average temperature be  $170^{\circ}$ , the difference between the temperature of the ascending and descending columns  $8^{\circ}$ , and the height ten feet; when similar weights of water are placed in each column, the hottest will stand .331 of an inch higher than the other; and this will give a velocity equal to 79.2 feet per minute. If the height be five feet, the difference of temperature remaining as before, the velocity will be only 55.2 feet per minute; but if the difference of temperature, in this last example, had been double the amount stated;—that is, had the difference of temperature

been  $16^{\circ}$ , and the vertical height of the pipe five feet,—then the velocity of motion would have been 79.2 feet per minute, the same as in the first example, where the vertical height was ten feet, and the difference of temperature  $8^{\circ}$ .”

But, in all these calculations, a considerable deduction must be made for the effects of friction. In the centre of the ascending pipe, the heated particles meet with the smallest amount of obstruction, and there the motion is quickest; but at and near the circumference of the pipe, the retarding effects of friction are most apparant. In the descending pipe the friction is less, for the water descends more as a whole, and is, moreover, assisted by the gravity of the mass. In an apparatus where the length of pipe is not great, where the pipes are of large diameter, and the bends and angles few, a large deduction from the theoretical amount must still be made, to represent, with anything like accuracy, the true velocity; and Mr. Hood states, that in more complex apparatus, the velocity of circulation is so much reduced by friction, that it will sometimes require from 50 to 90 per cent., and upwards, to be deducted from the calculated velocity, in order to obtain the true rate of circulation.

The amount of friction not only varies according to the arrangement of the apparatus, but also according to the size of the pipes. It is much greater in small pipes than in large one, on account of the relatively larger amount of surface in the former; besides this, small pipes cool quicker than large ones, and this increases the velocity of the circulation, and with it, the friction is also increased. When the velocity with which the water flows, is the same in pipes of different sizes, the relative amount of friction is as follows:—

Diameter of the pipes, $\frac{1}{2}$ inch,	1 in.	2 in.	3 in.	4 in.
The amount of friction, 8	4,	3,	1.3,	1.

So that, if the friction in a pipe of 4 inches diameter be represented by 1, the friction of a pipe 2 inches in diameter is twice as much, and a 1-inch pipe four times as much. By

increasing the velocity, the friction increases nearly as the square of the velocity; but as the water in a hot-water apparatus circulates with various degrees of speed in its different parts, it is not easy to calculate the amount of friction from this cause.

It will be seen, then, that when all the deductions are made, the circulation of the water is produced by a very feeble power, so that, as may be supposed, a very slight cause is sufficient to neutralize it. Mr. HOOD has known so trifling a circumstance as a thin shaving accidentally getting into a pipe, effectually to prevent the circulation in an apparatus otherwise perfect in all its parts.

But the great point to be attended to, is so to dispose the pipes, that the water, in its descent, may not be obstructed by differences of level, or angles in the pipes, where air may accumulate; for this, by dividing the steam, effectually prevents the circulation.

With respect to the accumulation of air in the pipes, every part of the apparatus, where an alteration of level occurs, must be furnished with a vent for the air.

When it is required to heat a number of separate stories by the same boiler, one of two methods may be adopted. The vertical pipe from the boiler may be carried up to the highest story, and the return-pipe meander through each story, until it finally terminates in the boiler. But it is obvious, that in such case, the top story will get the larger share of the heat, and the lower stories will be gradually less heated, on account of the cooling of the water in its passage to the boiler. The second method is to supply each story with a separate range of pipes branching out from the main pipe, and returning either together, or separately, into the boiler. The application of this principle, however, requires caution, for if the branch pipes are simply inserted into the side of a vertical ascending pipe, the hot current may pass by instead of flowing into them.

In some arrangements, the hot ascending current of the

vertical main is made to discharge into an open cistern at the top, and from the bottom of this cistern the various flow-pipes are made to branch off. By this means, the expense of cocks or valves is avoided; for by driving a wooden plug into one or more of the pipes which open into the cistern, the circulation will be stopped until the apparatus is heated; but, in that case, water will flow back through the return-pipe. This, however, may be prevented, by bending a lower portion of the return-pipe into the form of an inverted siphon. This will not prevent the circulation, when the flow-pipe is open; but if that be closed by a plug in the cistern, the hot water will not return back through the lower pipe. Any sediment that may accumulate in the siphon may be removed, from time to time, by taking off the cap at the lower part of the bend.

In such an arrangement, the vertical main pipe need not be of larger diameter than the branches, unless these extend to a very considerable distance, and then the diameter of the main pipe may be somewhat enlarged. It is not, however, desirable to increase the diameter of the main, because it is an object to economize the heat in this pipe, and there are circumstances in which a small main loses less heat than a large one. If one main pipe, eight inches in diameter, supply four branches in a given time, it is evident, that by reducing the main to four inches in diameter, the water must travel four times faster through the smaller pipe to perform the same amount of work; and, under such circumstances, the water will lose only half as much heat in passing through the small main as it would do in ascending the larger one, for the loss of heat sustained by the water is directly as the time and the surface conjointly.

Hence, in warming by the same boiler two rooms separated from each other by a considerable distance, the pipe connecting the two rooms may be of smaller diameter than the pipes used for diffusing the heat. A pipe of one inch diameter may be used to connect pipes four inches in diameter

The great specific heat of water, whereby it is enabled to retain its heat for a very long time, has been already shown to be a great advantage of this method of warming buildings. The rate at which this apparatus cools, depends chiefly on the quantity of water contained in it with respect to the amount of surface exposed, and the excess of temperature of the apparatus above that of the surrounding air; but for temperatures below the boiling-point, this last circumstance need only be taken into account in estimating the velocity with which this apparatus cools. Now, the variation in the rate of cooling for bodies of all shapes, is inversely as the mass divided by the superficies. In cylindrical pipes, the inverse number of the mass divided by the superficies is exactly equal to the inverse of the diameters; so that, supposing the temperature to be the same in all,

In pipes of	-	-	-	-	-	-	1	2	3	4 inches diameter.
The ratio of cooling will be	-	-	-	-	-	-	4	2	1.3	1

That is, a pipe of one inch in diameter will cool four times as quickly as a pipe four inches in diameter, and so on. These ratios multiplied by the excess of heat in the pipes above that of the surrounding air, will give the relative rates of cooling for different temperatures below  $212^{\circ}$ ; but if the temperatures be the same in all, the simple ratios given above will show their relative rate of cooling without multiplying by the temperatures.

These calculations supply practical rules for estimating the size of the pipes under different circumstances. If the heat be required to be kept up long after the fire is extinguished, large pipes should be used; if, on the contrary, the heat is not wanted after the fire is put out, then small ones will answer the purpose. Pipes of larger diameter than four inches should never be used, because they require a very long time in being heated to the proper temperature. Pipes of four inches in diameter are well adapted for hot-houses, green-houses, and conservatories. Pipes of two or three

inches may be used for warming churches, factories, and dwelling-houses; such pipes retain their heat for a sufficient length of time, and they can be more quickly and more intensely heated than larger pipes, so that, on this account, a smaller quantity will often suffice.

With respect to the quantity of pipe required for warming a building of ascertained size, it is necessary to bear in mind the rate at which a given quantity of hot water, in an iron pipe will impart its heat to the surrounding air. Now, it has been shown by Mr. Hood, that the water contained in an iron pipe four inches in diameter internally, and four and a half inches externally, loses .851 of a degree of heat per minute, when the excess of its temperature is  $125^{\circ}$  above that of the surrounding air; and as one cubic foot of water, in losing  $1^{\circ}$  degree of its heat, will raise the temperature of 2,990 cubic feet of air the like extent of  $1^{\circ}$ , so one foot length of four-inch pipe will heat 222 cubic feet of air  $1^{\circ}$  per minute, when the difference between the temperature of the pipe and the air is  $125^{\circ}$ .

We must now take into account the loss of heat per minute, arising from the cooling power of glass, ventilation, radiation, cracks in doors and windows, and other causes. An allowance of from three and a half to five cubic feet of air ought to be made per minute for each person in the room; so that, for the purpose of respiration, this quantity will have to be discharged, and an equal supply of air brought in to be warmed.

One square foot of glass will cool 1.279 cubic feet of air as many degrees per minute as the internal temperature of the room exceeds the temperature of the external air. If the difference between them be  $30^{\circ}$ , the 1.279 cubic feet of air will be cooled  $30^{\circ}$  by each square foot of glass; that is, as much heat as is equal to this will be given off by each square foot of glass.

From these and other calculations, for which we must refer to Mr. Hood's able work, the following corollary is

drawn: "The quantity of air to be warmed per minute in habitable rooms and public buildings, must be three and a half cubic feet for each person the room contains, and one and a quarter cubic feet for each square foot of glass. For conservatories, forcing-houses, and other buildings of this description, the quantity of air to be warmed per minute must be one and a quarter cubic feet for each square foot of glass which the building contains. When the quantity of air required to be heated has been thus ascertained, the length of pipe which will be necessary to heat the building, may be found by the following rule: multiply 125 (the excess of temperature of the pipe above that of the surrounding air) by the difference between the temperature at which the room is purposed to be kept when at its maximum, and the temperature of the external air; and divide this product by the difference between the temperature of the pipes and the proposed temperature of the room; then, the quotient thus obtained, when multiplied by the number of cubic feet of air to be warmed per minute, and this product divided by 222 (the number of cubic feet of air raised 1° per minute by one foot of 4-inch pipe) will give the number of feet in length of pipe four inches diameter, which will produce the desired effect."

When 3-inch pipes are used, the quantity of pipe required to produce the same effect will, of course, be different. To obtain it, the number of feet of 4-inch pipe obtained by the above rule must be multiplied by 1.33. If 2-inch pipe be used, the quantity of 4-inch pipe must be multiplied by two.

If we wish to determine the quantity of pipe required to maintain a constant temperature of 75° in a hot-house, we must suppose the external air occasionally to fall as low as 10°, and calculate from this temperature. The amount of heat to be supplied by the pipes is obviously that which is expended by the glass, the cooling power of which is exactly proportioned to the difference between the internal and the

external temperature, the actual cubical contents of the house making no difference in the result. If such a house have 800 square feet of glass, it can easily be calculated from the preceding data, that this quantity will cool down 1,000 cubic feet of air per minute from  $75^{\circ}$  to  $10^{\circ}$ , which will require 292 feet of 4-inch pipe. If the maximum temperature of the pipe be  $200^{\circ}$ , and the water be  $40^{\circ}$  before lighting the fire, the maximum temperature will be attained in about four hours and a half; with 3-inch pipe in about three hours and a quarter; and with 2-inch pipe in about two hours and a quarter—depending, however, upon the structure of the furnace, and the quantity of coal consumed. If the external temperature be higher than  $10^{\circ}$ , the effect will be produced in a proportionally short time.

In churches and large public rooms, with an average number of doors and windows, and moderate ventilation, a more simple rule will apply for ascertaining the quantity of pipe required. Where a number of persons are assembled, a large amount of heat is generated by respiration, so that a very moderate artificial temperature is sufficient to prevent the sensation of cold. In such a case, the air does not require to be heated above  $55^{\circ}$  or  $58^{\circ}$ , and the rule is to take the cubical measurement of the space to be heated, and dividing this by 200, the quotient will be the number of feet of 4-inch pipe required.

The efficiency of any form of hot-water apparatus will, of course, greatly depend on the boiler, which ought to be so constructed as to expose the largest amount of surface to the fire in the smallest space; to absorb the heat from the fuel, so that as little as possible may escape up the chimney; to allow free circulation of the water throughout its entire extent, and not be liable to get out of order by constant use. A variety of boilers are figured in Mr. HOOP'S work, and their respective merits considered on scientific grounds. One of these boilers is thus described: It is of cast-iron, and the part exposed to the fire is covered with a series of ribs



two inches deep, and about one-fourth or three-eighths of an inch thick, radiating from the crown of the arch at an average distance of two inches from each other. These ribs greatly increase the surface exposed to the fire, exactly where the effect is greatest; for being immediately over the burning fuel, it receives the whole of the heat radiated by the fire. The form of this boiler being hemispherical, will also expose the largest amount of surface within a given area. The boiler being of wrought-iron, and, therefore, thinner than cast-iron, absorbs the greatest amount of heat from the fuel.

With respect to the size of the boiler, it has been shown by experiment that four square feet of surface in an iron boiler will evaporate one cubic foot of water per hour when exposed to the direct action of a tolerably strong fire. The same extent of heating surface which will evaporate one cubic foot of water per hour from the temperature of  $52^{\circ}$ , will be sufficient to supply the requisite amount of heat to 232 feet of 4-inch pipe, the temperature of which is required to be kept  $140^{\circ}$  above the surrounding air; or one square foot of boiler surface exposed to the direct action of the fire, or three square feet of flue surface, will supply the necessary heat to about 58 superficial feet of pipe; or, in round numbers, one foot of boiler to 50 feet of pipe. But as this is the maximum effect, a somewhat larger allowance ought in general to be made. If the difference of temperature be  $120^{\circ}$  instead of  $140^{\circ}$ , the same surface of boiler will supply the requisite amount of heat to one-sixth more pipe, and if the difference be only  $100^{\circ}$ , the same boiler will supply above one-third more pipe than the quantity stated.

With respect to the furnace, the rate of combustion of the fuel will depend chiefly on the size of the furnace-bars, provided the furnace door be double and fit tightly. The ash-pit should also be provided with a door to exclude the excess of air when the fire is required to burn slowly. A dumb-plate should also be provided, to cause the combustion

to be most active at the hinder part of the furnace, instead of directly under the boiler. The fuel will thus be gradually coked, the smoke consumed, and the fuel economized.

In an apparatus, containing 600 feet of 4-inch-pipe, the area of the furnace-bars should be 300 square inches, so that 14 inches in width and 22 inches in length will give the amount of surface required. To obtain the greatest heat in the shortest time, the area of the bars should be proportionally increased, so that a larger fire may be obtained. The fire ought at all times to be kept thin and bright, and to obtain a good effect from the fuel, one pound weight of coal ought to raise 39 lbs. of water from  $32^{\circ}$  to  $112^{\circ}$ .

The best kind of pipes for hot water apparatus are those with socket-joints; flange-joints having long been out of use for this purpose. Where the socket-joints are well made, there is no fear of leakage, for the pipes themselves will yield before the joints will give way, or before the faucet end of one pipe can be drawn out of the socket of the other. The joints must be well caulked with spun-yarn, and filled up with iron cement, or with a cement made of quick-lime and linseed oil.

Soft or rainwater ought always to be used in the hot-water apparatus, because, if hard water be used, its salts will form a sediment or crust in the boiler, and interfere with its action. But as there is very little evaporation from this kind of apparatus, the boiler will not require cleaning out for years, if a moderate degree of attention be bestowed on the water employed.

When the apparatus is not in use, care must be taken to prevent the water from freezing in the pipes, or the sudden expansive force of the water in freezing may crack them. If the apparatus is not likely to be used for some time during winter, it is better to empty the pipes than incur the risk of freezing. It has been proposed to fill the pipes with oil instead of water, and as the boiling point of oil is nearly three times higher than that of water, it was thought that

a temperature of  $400^{\circ}$  might be safely given to the pipes. It was found, however, that the oil at high temperatures became thick and viscid, and at length changed into a gelatinous mass, completely stopping all circulation in the pipes.

In the forms of apparatus to which the preceding details refer, the temperature of the water never rises to the ordinary boiling point ( $212^{\circ}$ ;) but we have now to notice a method, in which the temperature of the water is often beyond  $300^{\circ}$ ; this is the high-pressure method contrived by Mr. PERKINS. In its simplest form, the apparatus consists of a continuous or endless-pipe, closed in all parts, and filled with water. There is no boiler to this apparatus, its place being supplied by coiling up a portion of the pipe (generally one-sixth of the whole length) and arranging this in the furnace. The remaining five-sixths of the pipe are heated by the circulation of the hot water, which flows from the top of the coil, and cooling in its progress through the building, returns to the bottom of the coil to be re-heated. The diameter of the pipe is one inch externally, and half an inch internally, and is formed of wrought-iron. The coil in the furnace being entirely surrounded by the fire, the water is quickly heated, and becoming also filled with innumerable bubbles of steam, these impart a great specific levity to the ascending current. At the upper part of the pipe, the steam bubbles condense into water, and uniting with the column in the return-pipe, which is comparatively cool, the descent is rapid in proportion to the expansion of the water in the ascending column; or, in other words, according to the relative specific gravities of the two columns of water.

As the expansive force of water is almost irresistible, in consequence of its extremely limited elasticity, it is necessary, in the high-pressure apparatus, to make some provision for the expansion of the water when heated. The necessity for this will appear from the fact, that water heated from  $39.45^{\circ}$  (the point of greatest condensation) to  $212^{\circ}$ ,

expands about  $\frac{1}{3}$  part of its bulk; and the force exerted on the pipes by this expansion, would be equal to 14,121lbs. on the square inch. The method adopted, is to connect a large pipe, called the expansion-pipe,  $2\frac{1}{2}$  inches diameter, with some part of the apparatus, either horizontally or vertically. It should be placed at the highest point of the apparatus, and at the bottom of the expansion-pipe is inserted the filling-pipe through which the apparatus is filled. While the apparatus is being filled with water, the expansion-tube is left open at the top; water is then poured in through the filling tube, and as it rises in the pipes, drives out the air before it. When the pipes are full, the filling-pipe and the expansion-tube are carefully closed with screw plugs. It is important to expel all the air from the pipes, and this is done, in the first instance, by pumping the water repeatedly through them. The expansion-pipe is, of course left empty, as its use is to allow the water in the pipes to expand on being heated, and thus prevent the danger of bursting. From 15 to 20 per cent. of expansion space is generally allowed in practice.

The furnace is generally so arranged in the building required to be heated, as to allow the tube proceeding from the top of the coil to be carried straight up at once to the highest level at which the water has to circulate; here the expansion-tube is situated, and from this point, two or more descending columns can be formed, which, after circulating through different and distant parts of the building, unite at length in one pipe, just before entering the bottom of the coil in the furnace.

The heat is communicated to the air of the rooms from the external surface of the pipes, which are coiled up and placed within pedestals, ranged about the room with open trellis-work in front, or they may be sunk in stone floors, placed behind skirtings, or in the fire-places of each floor, the flues being stopped, or arranged in any other convenient manner.

In consequence of the great internal pressure which these tubes have to sustain, considerable care is required in their manufacture. They are made of the best wrought-iron, rolled into sheets a quarter of an inch thick, and of the proper width. The edges are then brought nearly together, the whole length of the iron, which is generally about 12 feet. In this state it is placed in a furnace, and heated to a welding-heat. One end is then grasped by an instrument firmly attached to an endless-chain, revolving by steam-power, and a man applies a pair of circular nippers, which, when closed, press the tube into the required size, and which he holds firmly while the tube is drawn through them by the engine. The edges are thus brought into perfect contact, and are so completely welded after passing two or three times through the nippers, that a conical piece of iron driven into the end of the tube will not open it at the joint sooner than at any other part.

When the tubes are screwed together at each end, they are proved by hydrostatic pressure, with a force equal to 3,000lbs. on the square inch of internal surface.

When the tubes are properly arranged and fixed in the building, the whole apparatus is filled with water by a force-pump, and subjected to considerable pressure, before lighting the fire. In this way, faulty pipes or leaky joints are detected.

The tubes are joined by placing the ends within a socket, forming a right and left-hand screw, the edge of one tube having been flattened, and the other sharpened: they are then screwed so tightly together, that the sharpened edge of one pipe is indented in the flattened surface of the other. Another method of connecting the pipes is by a cone-joint. A double cone of iron is inserted into the ends of the pipes to be joined, and is made tight by two screw-bolts. This joint is quickly made, and is very strong.

The furnace varies in form and dimensions according to circumstances.

In the apparatus erected at the British Museum for warming the print-room and the bird-room, the furnace is in a vault in the basement story, and the pipes, entering a flue, are carried up about forty feet to two pedestals, one in each room; one containing 360 feet of pipe, and the other 400 feet. About 140 feet of pipe are employed in the flow and return-pipes in the flue, and 150 feet are coiled up in the furnace. In this way, 1,050 feet of pipe are employed. The apparatus is very powerful, and supplies the requisite amount of heat. The print-room is about 40 feet long by 30 feet wide, and the ceiling contains large sky-lights. The temperature of  $65^{\circ}$  can easily be maintained in this room during winter. The fire is lighted at 6, A. M., and is allowed to burn briskly till sufficient heat is produced in the rooms, when the damper in the flue is partially closed. A slow fire is thus maintained: at 11 A. M., a fresh supply of fuel is added, and this supports the fire till 4, P. M., when all the fires at the Museum are extinguished. The above details will suffice to show the nature and application of this apparatus.

The cabins of the ferry-boats on the Fulton Ferry, New York, and boats in other parts of the country, are warmed by water-pipes. These pipes run under the seats, on each side of the cabin. The advantages which this method of heating possesses will be apparent when it is stated that hot water and iron pipes are better conductors of heat than the air itself. Heat can be carried by pipes from one part of a room to the other, easier through the pipes than without them—the temperature of the room is more uniform.

We fully agree with Mr. RICHARDSON, that in any building where this apparatus is intended to be erected, it ought not to be introduced as an after-thought. "It should be remembered, that as its complete success and its economical character, depend, in a great measure, upon due consideration of its benefits being given at the commencement of a building, so it ought, in future, to engage the primary consideration of the architect and builder"

It is, however, of great importance, to ascertain whether this apparatus is perfectly safe, for even a doubt on the subject must be fatal to its general introduction. The average temperature of the pipes is stated to be generally about  $350^{\circ}$ ; but a very material difference in temperature, amounting sometimes to  $200^{\circ}$  or  $300^{\circ}$ , is said to occur in different parts of the apparatus, in consequence of the great resistance which the water meets with in the numerous bends and angles of this small pipe. The temperature of the coil will, of course, give the working effect of the apparatus, but the temperature of any part of the pipe will furnish data for estimating its safety; for whatever is the temperature, and, consequently, the pressure in the coil, must be the pressure on any other part of the apparatus; for by the law of equal pressures of fluids, an increased pressure at one part will generate an equally increased pressure at every other part of the system.

A very elegant method of ascertaining the temperature of a heated surface of iron or steel, consists in filing it bright, and then noting the color of the thin film of oxide which forms thereon.\* Mr. Hood states, that in some apparatus, if that part of the pipe which is immediately above the furnace be filed bright, the iron will become of a straw-color, showing a temperature of about  $450^{\circ}$ . In other instances, it will become purple=about  $530^{\circ}$ ; and, in some cases, of a full blue color= $560^{\circ}$ . Now, as there is always steam in some part of the apparatus, the pressure can be calculated from the temperature, and a temperature

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* Steel becomes a very faint yellow	-	at	-	430 deg. Fahr.
“ pale straw-color	-	“	-	450 “
“ full yellow	-	“	-	470 “
“ brown	-	-	“	490 “
“ brown, with purple spots	-	“	-	510 “
“ purple	-	-	“	530 “
“ blue	-	-	“	550 “
“ full blue	-	-	“	560 “
“ dark-blue, verging on black	-	-	-	600 “

of  $450^{\circ}$  = a pressure of 420lbs. on the square inch;  $530^{\circ}$  = 900lbs.; and  $560^{\circ}$  = 1,150lbs. per square inch.

Although these pipes are proved, at a pressure of nearly 3,000lbs. per square inch, and the force required to break a wrought-iron pipe of one inch external, and half an inch internal diameter requires 8,822lbs. per square inch on the internal diameter, yet these calculations are taken for the cold metal. By exposing iron to long-continued heat, it loses its fibrous texture, and acquires a crystalline character, whereby its tenacity and cohesive strength are greatly weakened.

In order to make this apparatus safe, Mr. Hood suggests that, instead of hermetically sealing the expansion-pipe, it should be furnished with a valve, so contrived, as to press with a weight of 135lbs. on the square inch. This would prevent the temperature from rising above  $350^{\circ}$  in any part: the pressure would then be nine atmospheres, which is a limit more than sufficient for any working apparatus where safety is of importance.

But, supposing the apparatus were to burst in any part, the effects would, by no means, resemble those which accompany the explosion of a steam-boiler. One of the pipes would, probably, crack, and the water, under high-pressure, escaping in a jet, a portion of it would be instantly converted into steam, while that which remained as water would sink to  $212^{\circ}$ . This would have the effect of scalding water under ordinary circumstances, but the high pressure steam would not scald, because its capacity for latent heat is greatly increased by its rapid expansion, on being suddenly liberated, so that instead of imparting heat, it abstracts heat from surrounding objects. The only real danger that would be likely to ensue, would be from the jet of hot water, and this must, in any case, be of trifling amount.



## VENTILATION.

As Nature is the best, as well as the earliest, teacher, we take our first example, in the history of ventilation, from the lower animals; and, we venture the assertion, that a more difficult, or apparently more hopeless problem, does not exist in our rooms and crowded assemblies, our mines and ships, than in the case about to be proposed.

Imagine a dome-shaped building, perfectly air-tight, except through a small hole at the bottom, capable of containing thirty or forty thousand animals, full of life and activity; every portion of the enclosed space that can be spared being filled with curious machinery; the problem is, how to warm and ventilate such a space, so as to maintain a proper temperature, and yet to give to every individual within it a proper supply of air.

Now, this is the condition of a common bee-hive, and we may remark, that if, with all our machines and contrivances, and scientific resources, the combined operation of warming and ventilating a room be difficult, or unsatisfactory, how infinitely more so must be that of a small bee-hive, crowded with bees, the greater part of the interior filled up with combs of waxen cells, and only one small opening for the ingress and egress of the inhabitants, or for the escape of foul air, and the entrance of fresh.

In a common hive, there is absolutely no other door or window, or opening, than this small entrance-hole; for, on taking possession of a new hive, the bees stop up all the cracks and chinks, with a resinous substance named *propolis*, for the purpose of keeping out insect depredators; and the proprietor, with the same object, generally plasters the hive to the stool, and, in order to keep off the rain, covers it with a heavy straw cap, or turns a large pan over it.

It must not be supposed that, because the vitality of insects is greater than that of warm-blooded animals, bees are not affected by the same agencies which affect us, for

they are so, and in a similar manner: they fall down apparently dead, if confined in a close vessel; they perish in gases which destroy us; they perspire and faint with too much heat; and are frozen to death by exposure to too much cold.

HUBER introduced some bees into the receiver of an air-pump. They bore a considerable rarefaction of the air without any apparent injury; on carrying it further, they fell down motionless, but revived on exposure to the air. In another experiment, three glass vessels, of the capacity of sixteen fluid ounces, were taken; 250 worker bees were introduced into one, the same number into another, and 150 males into the third. The first and the third were shut close, and the second was partially closed. In a quarter of an hour, the workers in the close vessel became uneasy; they breathed with difficulty, perspired copiously, and licked the moisture from the sides of the vessel. In another quarter of an hour, they fell down apparently dead. They revived, however, on exposure to the air. The males were affected more fatally, for none survived; but the bees in the vessel which admitted air, did not suffer. On examining the air in the two close vessels, the oxygen was found to have disappeared, and was replaced by carbonic acid: other bees, introduced into it, perished immediately. On adding a small portion of oxygen gas to it, other bees lived in it; but they became insensible instantly on being plunged into carbonic acid, and revived on exposure to the air: they perished irrecoverably in nitrogen and hydrogen gases. Similar experiments, performed with the eggs, the larvæ, and the nymphs of bees, proved the conversion of oxygen into carbonic acid, in all three states. The larvæ consumed more oxygen than the eggs, and less than the nymphs. Eggs, put into foul air, lost their vitality. Larvæ resisted the pernicious influence of carbonic acid better than the perfect insect would have done, but the nymphs died almost instantly therein.

These, and many other analagous experiments, prove

that the respiration of bees has a similar vitiating effect upon a confined atmosphere, as the respiration of larger animals, and that bees require constant supplies of fresh air, in the same manner as other living creatures. They also require their dwelling to be kept moderately cool. When, from any circumstance, such as exposure to the sun, overcrowding, or the excitement produced by fear, anger, or preparation for swarming, the temperature of the hive is greatly raised, the bees evidently suffer. They often perspire so copiously, as to be drenched with moisture; and on fine summer nights, thousands of them may be seen hanging out in festoons and clusters, for the purpose of relieving the crowded state of the hive.

On inquiring into the method adopted by the bees for renewing the air of the hive, HUBER was struck by the constant appearance of a number of the workers arranged on each side of the entrance-hole, a little within the hive, incessantly engaged in vibrating their wings. In order to see what effect a similar fanning would produce on the air of a glass receiver, containing a lighted taper, M. SENEBIER advised him to construct a little artificial ventilator, consisting of eighteen tin vanes. This was put into a box, on the top of which was adapted a large cylindrical vessel, of the capacity of upwards of 3,000 cubic inches. A lighted taper, contained in this vessel, was extinguished in eight minutes; but, on restoring the air, and setting the ventilator in motion, the taper burnt brilliantly, and continued to do so as long as the vanes were kept moving. On holding small pieces of paper, suspended by threads, before the aperture, the existence of two currents of air became evident; there was a current of hot air rushing out, and, at the same time, a current of cold air passing in. On holding little bits of paper or cotton near the hole of the hive, a similar effect was produced: they were impelled towards the entrance by the in-going current, and when they encountered the outgoing current they were repelled with equal rapidity.

These two currents are established in the hive, by the fanning motion of the bees' wings. The worker bees perform the office of ventilators, and the number, at one time, varies from eight or ten to twenty or thirty, according to the state of the hive, and the heat of the weather. We have frequently watched their proceedings with interest. They station themselves in files, just within the entrance of the hive, with their heads towards the entrance, while another and a larger party stand a considerable way within the hive, with their heads also towards the entrance. They plant their feet as firmly as possible on the floor of the hive, stretching forward the first pair of legs, extending the second pair to the right and left, while the third, being placed near together, are kept perpendicular to the abdomen, so as to give that part a considerable elevation; then uniting the two wings of each side by means of the small marginal hooks with which they are provided, so as to make them present as large a surface as possible to the air, they vibrate them with such rapidity, that they become almost invisible. The two sets of ventilators, standing with their heads opposed to each other, thus produce a complete circulation of the air of the hive, and keep down the temperature to that point which is fitted to the nature of the animal. When a higher temperature is required at one particular spot, as, for example, on the combs containing the young brood, the nurse bees place themselves over the cells, and by increasing the rapidity of their respirations, produce a large amount of animal heat just where it is wanted. The carbonic acid, and other products of respiration, are got rid of by ventilation.

The laborious task of ventilating the hive, is seldom or never intermitted in the common form of hive, either by day or by night, during summer. There are separate gangs of ventilators, each gang being on duty for about half an hour. In winter, when the bees are quiet, and their respiration only just sufficient to maintain vitality, the ventilating pro-

cess is not carried on; but by gently tapping on the hive, its inmates wake up, increase the number of their respirations, and, consequently, the temperature of the hive, to such a degree, that the air becomes intolerably hot and vitiated. To remedy this, a number of worker bees go to the entrance of the hive, and begin to ventilate the interior as laboriously as in summer, although the open air be too cold for them to venture out.

Bearing in mind the details given in the introduction and the conclusion arrived at, that the animal frame is a true apparatus for combustion, we can understand how bees regulate the temperature of their hive: when greater heat is wanted, they increase the rapidity of their respirations, or in other words, they burn more carbon; but they get rid of the products of combustion, and also prevent the heat from accumulating, by the process of ventilation. Bees, in general, maintain a temperature of  $10^{\circ}$  or  $15^{\circ}$  above that of the external air; but, at certain periods, this temperature is greatly increased. Mr. NEWPORT observed, in the month of June, when the atmosphere was at  $56^{\circ}$  or  $58^{\circ}$ , that the temperature of the hive was  $96^{\circ}$  or  $98^{\circ}$ . This high temperature arose from the nurse bees incubating on the combs, and voluntarily increasing their heat by means of increased respiration. In winter, on the contrary, when only just sufficient heat is required to maintain vitality, less carbon is burnt, and the temperature of the hive is accordingly low. In one observation by Mr. NEWPORT at 7.15, A. M., on the 2nd January, 1836, when there was a clear, intense frost, and the thermometer in the open air stood a little above  $17^{\circ}$ , a thermometer permanently fixed in the hive, marked a temperature of  $30^{\circ}$ , or two degrees below the freezing-point. The bees were roused by tapping on the hive, and in the course of sixteen minutes, the thermometer rose to  $70^{\circ}$ , or  $53^{\circ}$  above the temperature of the external air. On another occasion, when the temperature of the hive had been raised to about  $70^{\circ}$ , the external air being

at 40°, the bees soon cooled it down to 57° by their mode of ventilation, and kept it at that point as long as the hive continued to be excited.

By this process of ventilation, bees get rid of noxious odors in the hive. HUBER found that, on introducing into the hive some penetrating vapor, disagreeable to the bees, they always increased the amount of ventilation, until they got rid of it. Humble-bees adopt the same method of dispelling pernicious odors; but it is remarkable, that neither their males, nor those of domestic bees, seem capable of using their wings as ventilators. "Ventilation is, therefore," says HUBER, "one of the industrial operations peculiar to the workers. The Author of Nature, in assigning a dwelling to those insects where the air can hardly penetrate, bestows the means of averting the fatal effects resulting from the vitiation of their atmosphere. Perhaps the bee is the only creature entrusted with so important a function, and which indicates such delicacy in its organization."

The circumstances under which our rooms are placed, are far more favorable to ventilation than the bee-hive. Whether the ventilation be left to chance, or whether any special apparatus be erected for the purpose, the foul, vitiated air must be got rid of, and fresh air, adapted to the purposes of respiration, admitted in sufficient quantity—that is, at the rate of about four cubic feet per minute, for each individual in the room. The air must leave the room at certain openings, or be drawn out of it thereby at this rate, while a similar amount of fresh air must enter to supply the loss; or, to speak more accurately, the force or impetus of the incoming air ought slightly to compress the air of the room, and assist the efflux of the vitiated air, and this, in its turn, ought to be so heated, as to have a certain amount of ascensional force over that of the incoming air. In some cases, mechanical means are necessary to expel the air, such as fanners, bellows, pumps, &c.; but it is generally more convenient, as well as economical, to trust to the natural

method of getting rid of the vitiated air, by making certain ventilating tubes or openings at the highest point of the room towards which the hot air tends to flow.

The same cause which produces the draught of common chimneys, and of the glass chimneys of our oil and gas lamps will, if circumstances be favorable, set in motion and discharge the vitiated air of our rooms, at the same time that it brings in the fresh. For example, the air of a common chimney, under the influence of the fire, expands according to a law applicable to all gases, namely,  $\frac{1}{480}$  of its volume for each degree of Fahrenheit's scale from  $32^{\circ}$  to  $212^{\circ}$ . Now, if a chimney or ventilating flue were ten feet high, and the temperature of the column of air within it were raised  $20^{\circ}$  above the temperature of the external air, the expansion would be  $\frac{20}{480}$ ths, or  $\frac{1}{24}$ th of its bulk. This would so far diminish the specific gravity of the heated column, that it would require  $10\frac{1}{2}$  feet thereof to balance a column of the external air of 10 feet. It has been already stated, that the velocity of efflux is equal to the velocity of a heavy body falling through the difference in height between the two columns; and in the case before us, the difference of five inches is equal to 5.174 feet per second, or 310 feet per minute; and this is the velocity with which a heated column of air would be forced through the ventilating tube or chimney: and supposing the dimensions of this to be one foot square, then 310 cubic feet of air would escape per minute. This, however, is the theoretical amount, which does not take into account the retarding effects of friction arising from the roughness of the tube, or any angles or bends in it, or the increased density of the hot air from the presence of carbon from the fuel, in a minutely-divided state. In practice, it is usual to allow from one-fourth to one-third for the effects of friction.

As the velocity of a falling body, in a second of time, is known to be eight times the square root of the height of the descent, in decimals of a foot, so the velocity of dis-

charge per second, through vent-tubes or chimneys, may be briefly stated as equal to eight times the square root of the difference in height of the two columns of air, in decimals of a foot. This number, reduced one-fourth for friction, and the remainder multiplied by 60, will give the true velocity of efflux per minute; and the area of the tube, in feet, or decimals of a foot, multiplied by this last number, will give the number of cubic feet of air discharged per minute.

In estimating the total height of a column of heated air, we must calculate the total vertical height from the floor of the room to be ventilated to the top of the tube, where it discharges into the open air. All horizontal bends and angles may be neglected, for these make no difference in the vertical height, but only increase the amount of friction, and deprive the heated column of a portion of its ascensional force, by cooling. As the vertical height of the column gives the velocity of discharge in the ratio of the square root of the height of the column, it is necessary, where several vent-tubes be employed, that they all be of the same vertical height, or the highest vent will prevent the efficient action of the lower ones, so that there may actually be a smaller discharge through two tubes than through one only.

So, also, when several openings are made above the level of the floor of a room, the highest may be the only one capable of acting as an abduction-tube, the other lower openings often serving as induction-tubes, discharging cold air into the room instead of taking it out; and, in doing so, lower the temperature of the hot, vitiated air, and prevent it from escaping; thus not only causing the bad air to be breathed over again, but filling the room with unpleasant draughts. But if the highest abduction-tube be too small to carry off the requisite quantity of hot air, the tube next below it in elevation at any part of the room will act as an abduction-tube.

If the lower openings for the admission of cool, fresh air



be too small in proportion to those for the escape of the hot air, a current of cold air will descend through one part of the hot-air tube, and the hot air will ascend through another part of the same tube—an effect which we have already seen takes place in the ventilation of a bee-hive. This effect may also be shown by a very pleasing experiment: Place a lighted taper in a flat dish, and cover it with a glass receiver, furnished with a long glass chimney placed immediately over the flame. If the bottom of the receiver does not come into very close contact with the dish, enough air will enter to support combustion, and the draught or current of hot air will escape up the chimney, and the taper will continue to burn for any length of time. If we now shift the receiver a little on one side, so that the flame may not be immediately under the chimney, the products of combustion will impinge upon the glass, and cooling down and mingling with the air of the receiver, will contaminate it so much, that the taper immediately begins to burn dimly, and will soon be extinguished. On bringing the chimney over the flame, it will speedily improve in appearance; the smoke and other products of combustion will be rapidly discharged, and the receiver will become bright and transparent as before. But suppose we cut off all communication with the external air from below by pouring a little water into the dish, so as to cover the mouth of the receiver, we shall then have the case of a room which is provided with a vent-tube near the ceiling, but has no provision for admitting fresh air from any lower openings: in such case, the fresh air will seek to enter by the ventilating tube. If this be large enough, the outgoing hot air and the incoming cool air will divide the tube into two parts. But if, as in the experiment before us, the ventilating tube or chimney be too narrow, the hot and cold currents will interfere with each other: the tendency of the hot air to rise and of the cold air to descend, will prevent the escape of the one and the entrance of the other, and the taper will soon be extin-

guished for want of fresh air. But if the chimney be divided into two portions by a flat strip of tin plate passed down it, and the taper be lighted and placed in its former position, it will continue to burn for any length of time; for, by this arrangement, the two currents of hot and cold air are prevented from interfering with each other; the hot air will pass up one channel and escape, and the cold air will descend the other channel to feed the flame. By holding a piece of smoking paper or the glowing wick of a taper on one side of the chimney, the smoke will be drawn down, thereby indicating the descending current of cool air; while, on the other side, the smoke will be driven up by the ascending current of heated air.

In the same manner, these counter-currents may be frequently noticed in churches and other crowded places, where due provision is seldom made for the entrance of fresh air, and the escape of the foul. It is usual in summer to mitigate the effects of the hot, vitiated atmosphere, by throwing open the windows. A portion of the foul air, it is true, escapes by these channels, but a counter-current immediately sets in through each of them, exposing the persons near them to the dangerous effects of draught, and also cooling the foul air which is seeking to escape, and sending it down to be breathed over again.

Now, in order that these open windows or any other ventilating openings be effective, it is necessary that the lower openings for the admission of fresh air be as numerous, or, at least, as large as the upper ones, and larger, if possible. By making these lower openings, or induction-pipes, or doors, or valves, or any other contrivances both numerous and capacious, the entering current is broken up and divided, and cold draughts are avoided. This remark is equally applicable to fresh air, which has been previously warmed by an artificial process; for, by admitting it into the room through numerous channels, it distributes its warmth more equally, and does not rise to the ceiling too rapidly.

Ventilation is more difficult in summer than in winter, because, in warm weather the difference between the internal and the external temperature is much less than in cold weather. In all cases of spontaneous ventilation, it will therefore be necessary in summer to increase the number or the size of the ventilating tubes. When these tubes are constructed, their number and size ought to be adapted to the full amount of summer ventilation. In winter some of them can be closed, and others, if too large, ought to admit of being reduced in size. Perforated zinc is now getting into use as a ventilator. The pane of glass furthest from the fire-place and in the upper row is taken out, and its place supplied with a sheet of zinc, having 220 perforations to the square inch. Panes of perforated glass are also abundantly supplied, as well as glass louvres.

TREDGOLD has given some very sensible directions for the ventilation of a church, which, of course, apply equally to any other public building, and, to a certain extent, to private houses. He advises, that the spaces for the admission of the cold air be abundantly large, and divided as much as possible ; they should be in or near the floor, so that the air may not have to descend upon any one ; by making the openings large, and covering them on the inside with rather close wire-work (sixty-four apertures to the square inch) most of the current may be prevented ; and it may be still further prevented by bringing tubes under the paving to admit fresh air into the central parts of the church. Of course these openings must be provided with shutters, so as to close them when desirable. Provision should be made for the escape of the warm air at different parts of the ceiling, through air-trunks furnished with registers. The form of the mouth of the vent-tube, is a circular aperture, with a balanced circular register-plate, to close it. This plate should be larger than the aperture, in order that the air may be drawn into a horizontal current, for the purpose of taking away the portion of air next the ceiling. If the

tube were left without a plate, the air immediately under it would press forward up the tube, and very little of the worst air which collects at the ceiling would escape.

A flat or level ceiling is not well adapted to the purposes of ventilation ; but a still worse form of ceiling is that which is divided into coffers, for in these the air collects, gets cooled, and descends. For effective ventilation, ceilings ought always to be dome-shaped, coved, arched, groined, or of the form of a truncated pyramid, so as to rise in the centre, and at the centre or most elevated point, the ventilating tube should be placed. When curved lines are not used, ceilings of this form ought always to be adopted; they are not much more expensive than flat ones; they have a better effect, and are vastly superior as far as ventilation is concerned, supposing an opening be made in the central or highest point for the escape of the vitiated air.

As it is not always possible to conduct the vent-tube at once in a vertical line from the highest point of the ceiling, there is no objection to giving it a horizontal direction for some distance.

Where the vent-tubes can be carried up vertically from the ceiling to the top of the building, it is always better to do so, because the friction of the hot ascending current is thereby diminished. If the vent be made through the ceiling of a church into the space in the roof, and from this space, an air-tube be taken up within the steeple or bell-turret, an effectual ventilation may be obtained without adding outlets to the roof. Where external appearance is less regarded, a common louvre-boarded top, for an outlet from the roof, will answer. All side and end windows should be kept closed ; for if the apertures at the ceiling be of the proper size, and due provision be made for supplying fresh air, these open windows, as already explained, will diminish, not increase the amount of ventilation. The reason has been already stated why ventilation is difficult to maintain in warm weather. Of course, it becomes especially

so in very calm, warm weather. Mr. TREDGOLD gives a case of this kind : Suppose we wish to provide ventilation sufficient to prevent the internal air from being of a higher temperature than  $5^{\circ}$  above that of the external air. Now, if the external air be at  $70^{\circ}$ , we shall not be able to keep the internal temperature down to  $75^{\circ}$  with a less escape of air than  $2\frac{1}{2}$  cubic feet per minute for each person ; because each person will heat at least that quantity of air  $5^{\circ}$  in a minute, at these temperatures. When a church contains 1,000 persons, and the height from the floor to the top of the tube is 49 feet, the sum of the apertures that will allow 2,200 cubic feet of air per minute to escape, when the excess of temperature is  $5^{\circ}$ , must be equal to 12 square feet. If the height be only 36 feet, the size of the aperture must be 14 square feet, nearly. When the ceiling is level, this area should be divided among five or more ventilators, disposed in different parts of the ceiling ; but in a vaulted or arched roof, three are recommended to be placed in the highest part of the ceiling.

It is also recommended, that the openings for admitting cold air be about double the area of those at the ceiling. The air should not be taken from very near the ground, nor from a confined place. In designing and constructing a new building, flues might be made for the special purpose of supplying the interior with fresh air. Each flue might open in the cornice, pass down between the piers, and under the flooring of the church or other building, and terminate in apertures which would be covered with gratings. By disposing some of these flues on each side of the church, they would act with the wind in any direction. These exterior openings should, however, be covered with a grating, to prevent birds from building in them, and thus stopping them up.

In some of the old buildings, which still excite the admiration of persons of cultivated taste, by the beauty of their arrangements and architectural details, we sometimes

meet with special provision for ventilation, arranged on the truest principles. Thus, in the "Hall of the Baths" in the Alhambra, at Granada, the roof is perforated with ventilating openings, and is not only of the best possible form for the purpose of ventilation, but the openings themselves are of the best possible shape, being wider at the lower extremity than at the upper; and in order that these openings may present the least possible amount of friction to the outgoing air, they are provided with short tubes of baked earth, covered with a green, vitreous glazing.

Such are the methods by which churches and other public buildings may be spontaneously ventilated. In the rooms of private houses, the ventilation must also be spontaneous, for if the slightest trouble be entailed on the inmates, even to the opening of a window, it will be neglected. The means of ventilation must be cheap, easily procurable, always in place, self-acting, not liable to get out of order, requiring no adjustment, no care whatever on the part of the inmates. It would seem impossible, at first view, to contrive anything at all likely to answer these conditions, and yet the thing has been done in the most perfect manner by that truly patriotic individual, Dr. ARNOTT, so well known for his water-bed, his stove, and other inventions, which he has freely presented to the public, without seeking or desiring any emolument to himself.

In the autumn of 1849, when the cholera was raging in England, the Board of Health recommended, in one of their notifications published in the *London Gazette*, that in every badly-ventilated dwelling, "considerable and immediate relief may be given by a plan suggested by Dr. ARNOTT, of taking a brick out of the wall near the ceiling of the room, so as to open a direct communication between the room and the chimney. Any occasional temporary inconvenience of down-draught will be more than compensated by the beneficial results of this simple ventilating process."

A few days after this authoritative recommendation of

this contrivance, and in consequence of numerous applications for further information on the subject, Dr. ARNOTT addressed a letter to the *Times* newspaper, dated September 22, 1849. This admirable letter is so interesting and so pertinent, that we venture to transfer nearly the whole of it to our pages :—

“ I assume,” says Dr. ARNOTT, “ that most of your readers already understand, or will now learn, that the air which we breathe, and which is used to stuff air-pillows, consists of material elements, as much as the water which we drink, or the food which we eat—indeed, consists altogether of oxygen and nitrogen; the first of which forms also seven-eighths, by weight, of the substance of water, and the other nearly one-fifth, by weight, of the substance of flesh; and that there is surrounding our globe, to a depth of about fifty miles, a light, fluid ocean of such air, called the atmosphere, into which, near the surface of the earth, certain impurities are always rising from the functions of animal and vegetable life and the decomposition of substances in putrefaction, combustion, &c., just as into the sea and great rivers some impurities are always entering from the sewers—all which impurities, however, are quickly so diluted or dissipated in the great masses, as to become absolutely imperceptible, and eventually, by the admirable process of nature, are decomposed and changed, so that the great oceans of air and water retain ever their state of perfection. I assume, further, that your readers know that fresh air for breathing is the most immediately urgent of the essentials to life, as proved by the instant death of any one totally deprived of it through drowning or strangulation; and by the slower death of men compelled to breathe over again the same small quantity of air, as when lately seventy-three passengers were suffocated in an Irish steamboat, of which the hold was shut up for an hour, by closely-covered hatches; and by the still slower death, accompanied generally by some induced form of chronic disease, of persons condemned to

breathe habitually impure air, like the dwellers in crowded, ill-ventilated rooms, and foul neighborhoods; and, lastly, as proved by the fact, that pestilence or infectious diseases are engendered or propagated almost only where impurities in the air are known to abound, and particularly where the poison of the human breath and other emanations from living bodies are allowed to mingle in considerable quantity—as instanced in the gaol and ship fevers, which so lately, as in the days of the philanthropist Howard, carried off a large proportion of those who entered gaols and ships; and, as instanced in that fearful disease, which, at the Black Assizes at Oxford, in July, 1577, spread from the prisoners to the Court, and within two days had killed the judge, the sheriff, several justices of the peace, most of the jury, and a great mass of the audience, and which afterwards spread among the people of the town. This was a fever which did its work as quickly as the cholera does now.

“Assuming that these points are tolerably understood, I shall proceed to show, that from faults in the construction and management of our houses, many persons are unconsciously doing, in regard to the air they breathe, nearly as fishes would be doing in regard to the water they breathe, if, instead of the pure element of the vast rivers or boundless sea streaming past them, they shut themselves up in holes near the shores filled with water defiled by their own bodies, and from other foul sources. And I shall have to show, that the spread of cholera in this country has been much influenced by the gross oversights referred to.

“All the valued reports and published opinions on cholera go far to prove, that in this climate, at least, any foreign morbid agent or influence which produces it, comes comparatively harmless to persons of vigorous health, and to those who are living in favorable circumstances; but that if it find persons with the vital powers much depressed or disturbed from any cause, and even for a short time, as happens from intemperance, from improper food or drink, from



great fatigue or anxiety—but, above all, from want of fresh air, and, consequently, from breathing that which is foul, it readily overcomes them. It would seem as if the peculiar morbid agent could as little, by itself, produce the fatal disease, as one of the two elements concerned in common gas explosion—namely, the coal-gas and the atmospheric air—can alone produce the explosion. The great unanimity among writers and speakers on the subject, in regarding foul atmosphere as the chief vehicle and favorer, if not a chief efficient cause of the pestilence, is seen in the fact of how familiar to the common ear have lately become the words and phrases ‘malaria, filth, crowded dwellings, crowded neighborhoods, close rooms, faulty sewers, drains, and cess-pools—or total want of these—effluvia of graveyards,’ &c.; all of which are merely so many names for foul air, and for sources from which they arise. Singularly, however, little attention has yet been given, from authority, to the chief source of poisonous air, and to means of ventilation, by which all kinds of foul air may certainly be removed.

“A system of draining and cleansing, water-supply and flushing, for instance, to the obtainment of which, chiefly, the Board of Health has hitherto devoted its attention, can, however good, influence only that quantity and kind of aerial impurity which arises from retained solid or liquid filth within or about a house, but it leaves absolutely untouched the other and really more important kind, which, in known quantity, is never absent where men are breathing—namely, the filth and poison of the human breath. This latter kind evidently plays the most important part in all cases of a crowd, and, therefore, such catastrophes as that of the Tooring School, with 1,100 children, of whom nearly 300 were seized by cholera, of the House of Refuge for the Destitute, and of the two great crowded lunatic asylums here, where the disease made similar havoc,—for places so public as these, and visited daily by numerous strangers, could not be allowed to remain visibly impure with solid

and liquid filth, like the Rookery of St. Giles's, and other such localities. Now, good ventilation, which, although few persons comparatively are as yet aware of the fact, is easily to be had, not only entirely dissipates and renders inert the breath-poison of inmates, however numerous, and even of fever patients ; but in doing this, it necessarily at the same time carries away at once all the first-named kinds of poison, arising from bad drains, or want of drains, and thus acts as a most important substitute for good draining, until there be time to plan, and safe opportunity to establish such. It is further to be noted, that it is chiefly when the poison of drains, &c., is caught and retained under cover, and is there mixed with the breath, that it becomes very active, for scavengers, night-men, and grave-diggers, who work in the open air, are not often assailed with disease ; and in foul neighborhoods, persons like butchers, who live in open shops, or policemen, who walk generally in the open streets, or in Paris, the people who manufacture a great part of the town-filth into portable manure, suffer very little.

“To illustrate the efficacy of ventilation or dilution with fresh air, in rendering quite harmless any aerial poison, I may adduce the explanation given in a report of mine on fevers, in 1840, of the fact, that the malaria or infection of marsh fevers, such as occur in the Pontine marshes near Rome, and of all the deadly tropical fevers, affects persons almost only in the night. Yet the malaria or poison from decomposing organic matters which causes these fevers, is formed during the day, under the influence of the hot sun, still more abundantly than during the colder night ; but in the day, the direct beams of the sun warm the surface of the earth so intensely, that any air touching that surface is similarly heated, and rises away like a fire-balloon, carrying up with it, of course, and much diluting, all poisonous malaria formed there. During the night, on the contrary, the surface of the earth no longer receiving the sun's rays

soon radiates away its heat, so that a thermometer lying on the ground is found to be several degrees colder than one hanging in the air a few feet above. The poison formed near the ground, therefore, at night, instead of being heated and lifted, and quickly dissipated, as during the day, is rendered cold and comparatively dense, and lies on the earth a concentrated mass, which it may be death to inspire. Hence, the value in such situations of sleeping apartments near the top of a house, or of apartments below, which shut out the night air, and are large enough to contain a sufficient supply of the purer day air for the persons using them at night, and of mechanical means of taking down pure air from above the house to be a supply during the night. At a certain height above the surface of the earth, the atmosphere being nearly of equal purity all the earth over, a man rising in a balloon, or obtaining air for his house, from a certain elevation, might be considered to have changed his country, any peculiarity of the atmosphere below, owing to the great dilution effected before it reached the height, becoming absolutely insensible.

“Now, in regard to the dilution of aerial poisons in houses by ventilation, I have to explain, that every chimney in a house is what is called a sucking or drawing air-pump, of a certain force, and can easily be rendered a valuable ventilating pump. A chimney is a pump—first, by reason of the suction or approach to a vacuum made at the open top of any tube across which the wind blows directly; and, secondly, because the flue is usually occupied, even when there is no fire, by air somewhat warmer than the external air, and has, therefore, even in a calm day, what is called a chimney-draught proportioned to the difference. In England, therefore, of old, when the chimney-breast was always made higher than the heads of persons sitting or sleeping in rooms, a room with an open chimney was tolerably well ventilated in the lower part, where the inmates breathed. The modern fashion, how-

ever, of very low grates and low chimney openings, has changed the case completely, for such openings can draw air only from the bottom of the rooms, where generally the coolest, the last entered, and therefore the purest air, is found, while the hotter air of the breath, of lights, of warm food, and often of subterranean drains, &c., rises and stagnates near the ceilings, and gradually corrupts there. Such heated, impure air, no more tends downward again to escape or dive under the chimney-piece, than oil in an inverted bottle immersed in water will dive down through the water to escape by the bottle's mouth; and such a bottle or other vessel containing oil, and so placed in water with its open mouth downwards, even if left in a running stream, would retain the oil for any length of time. If, however, an opening be made into a chimney flue through the wall near the ceiling of the room, then will all the hot, impure air of the room as certainly pass away by that opening, as oil from the inverted bottle would instantly all escape upwards through a small opening made near the elevated bottom of the bottle. A top window-sash, lowered a little, instead of serving, as many people believe it does, like such an opening into the chimney flue, becomes generally, in obedience to the chimney draught, merely an inlet of cold air, which first falls as a cascade to the floor, and then glides towards the chimney, and gradually passes away by this, leaving the hotter impure air of the room nearly untouched.

“For years past, I have recommended the adoption of such ventilating chimney openings as above described, and I devised a balanced metallic valve, to prevent, during the use of fires, the escape of smoke to the room. The advantages of these openings and valves were soon so manifest, that the referees appointed under the Building Act added a clause to their bill allowing the introduction of the valves, and directing how they were to be placed, and they are now in very extensive use. A good illustration of the

subject was afforded in St. James's parish, where some quarters are densely inhabited by the families of Irish laborers. These localities formerly sent an enormous number of sick to the neighboring dispensary. Mr. TOYNBEE, the able medical chief of that dispensary, came to consult me respecting the ventilation of such places; and, on my recommendation, had openings made into the chimney flues of the rooms near the ceilings, by removing a single brick, and placing there a piece of wire gauze, with a light curtain-flap hanging against the inside, to prevent the issue of smoke in gusty weather. The decided effect produced at once on the feelings of the inmates was so remarkable, that there was an extensive demand for the new appliance, and, as a consequence of its adoption, Mr. TOYNBEE had soon to report, in evidence given before the Health of Towns Commission, and in other published documents, both an extraordinary reduction of the number of sick applying for relief, and of the severity of diseases occurring. Wide experience elsewhere has since obtained similar results. Most of the hospitals and poor-houses in the kingdom now have these chimney-valves; and most of the medical men and others who have published of late on sanitary matters, have strongly commended them. Had the present Board of Health possessed the power, and deemed the means expedient, the chimney openings might, as a prevention of cholera, almost in one day, and at the expense of about a shilling for a poor man's room, have been established over the whole kingdom.

"Mr. SIMPSON, the registrar of deaths for St. Giles's parish, an experienced practitioner, whose judgment I value much, related to me, lately, that he had been called to visit a house in one of the crowded courts, to register the death of an inmate from cholera. He found five other persons living in the room, which was most close and offensive. He advised the immediate removal of all to other lodgings. A second died before the removal took place, and soon after,

in the poor-house and elsewhere, three others died who had breathed the foul air of that room. Mr. SIMPSON expressed to me his belief that if there had been the opening described above, into the chimney near the ceiling, this horrid history would not have been to tell. I believe so too, and I believe there have been in London, lately, very many similar cases."

Among other modes of spontaneous ventilation, may be mentioned the *mulguf*, or wind-conductor, of the ancient Egyptians, and still in use in modern Egypt. It was erected at the top of the house, and consisted of a frame covered or enclosed on all sides, except at the mouths, which were open in the direction of the prevailing winds. The roof of the *mulguf* sloped down from each open end to the centre, where a partition divided it, and deflected the wind down into the apartments below. Mr. WILKINSON, in his work on Egypt, gives a view of part of Cairo, showing the *mulgufs* on the houses of the modern Egyptians. The ancient *mulgufs* were double, as shown in the figure, but the modern ones are single, and the opening is in the direction of the prevailing north-west wind. They consist of a strong frame-work, to which several planks of wood are nailed, according to the breadth and length proposed; and, if required of cheaper materials, reeds or mats, covered with stucco, are used instead of planks.

This contrivance acts on a similar principle to the *wind-sail* used on board ships, which consists of a sail spread out to the wind: from the lower part proceeds a cylinder of canvas, distended by hoops, which may be carried down through the hatches, to any deck or hold where fresh air is required. Its action depends on the force of the wind, and the mode of arranging it. It is of no use in calm weather, when ventilation is often most needed: and it is equally unavailable in stormy weather, when the hatches are battened down, and the men crowded below. Indeed, unless some contrivance could be made for getting rid of the vitiat-

ed air by other openings, the supply of fresh air by the wind-sail must always be partial and defective.

The next class of mechanical contrivances for ventilation, is that in which the aid of an attendant is required, either to maintain the ventilating machine in motion, or to superintend the mechanical power that does so. The simplest of these contrivances is the *fan*, which has been used from time immemorial, especially in warm climates, where it is often made of an enormous size, and being wielded by an attendant with a dexterity acquired by long practice, its effect is very powerful in giving motion to the air, and producing the sensation of coolness, by bringing a larger supply to the person, and abstracting the heat by its motion. The *punkah*, as commonly used in India, is nothing more than a gigantic fan, suspended in the centre of the apartment, above a bed or table. Attached to one side is a line, which passes out of the apartment through the wall, to an attendant on the outside, who thus gives motion to the large extended surface within, and thus prevents the air from stagnating.

A machine called the *zephyr* was proposed some years ago by Mr. DOBSON, for giving motion to the air of a room. Two sails, or punkahs, crossing each other at right angles, were mounted on a frame, and a rotary motion was given thereto, by suspending it from a case containing a mechanism like that of a bottle-jack. This case was suspended by lines passing over pulleys in the ceiling, and balanced by weights, so that the sails could be made to play at any elevation. In all these contrivances, motion is given to the air, but the rooms containing them are not ventilated thereby; the vitiated air is whirled and whisked about, but not driven out, and its place supplied by fresh air.

We have stated, as fully as the limits of this work will allow, the *principles* which should govern in warming and ventilating houses, so as to enable the reader to judge correctly as to the best mode to adopt in any particular case.

## CHAPTER XI.

## MODEL COTTAGE.

THIS CUT is an elevation of the Model Cottages erected by PRINCE ALBERT, near the Great London World's Fair Exhibition. We insert it, not on account of any intrinsic merits which it possesses, as adapted to American occupants, but as a compliment to its notoriety. The building is intended for four families—two on each floor. Each family will be blessed with one living-room, one bed-room and one pantry.

The only peculiarity in the Model Cottages, worthy of especial attention, is the "Hollow Brick," with which the walls are built. These brick are, it is claimed, more dry and warm than solid brick, and, at the same time, are twenty-five per cent cheaper in their cost.

The annexed section is illustrative of the construction represented in PRINCE ALBERT'S Model Houses. The span of the arches being increased over the living-rooms to 10 feet 4 inches, with a proportionate addition to their rise. The external springers are of cast-iron, with brick cores, connected with wrought-iron tie-rods.

1 and 2, represents the plan of window and door jambs, on alternate courses.

3. Partition block.

4 and 5. Plan of angles, on alternate courses.

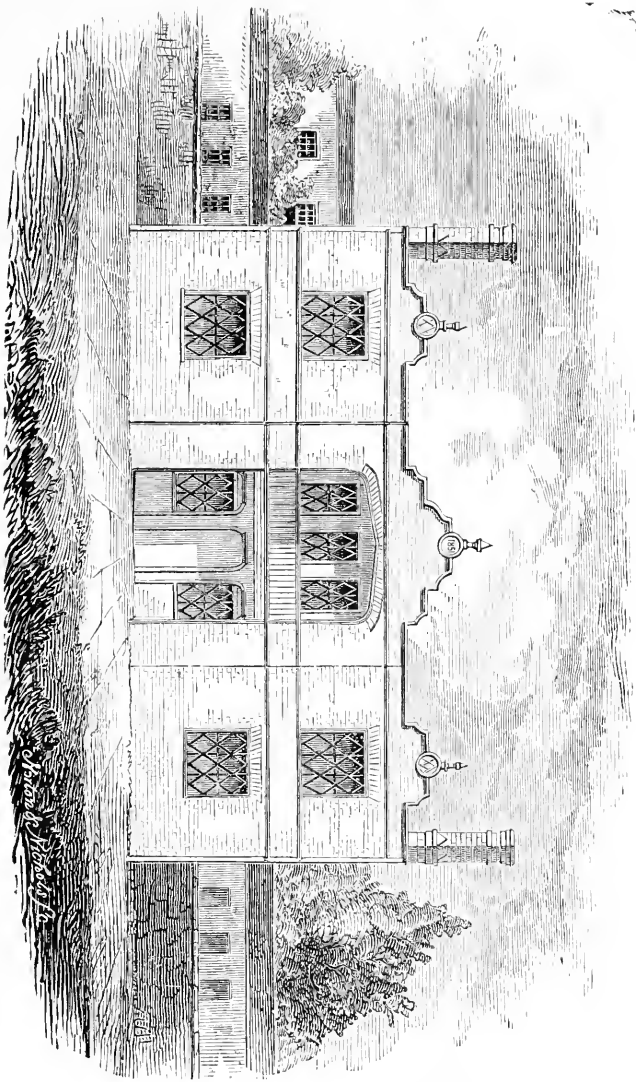
6. Square jamb and chimney brick.

7. Section of a one foot and two inch wall.

8. Internal door and chimney brick.

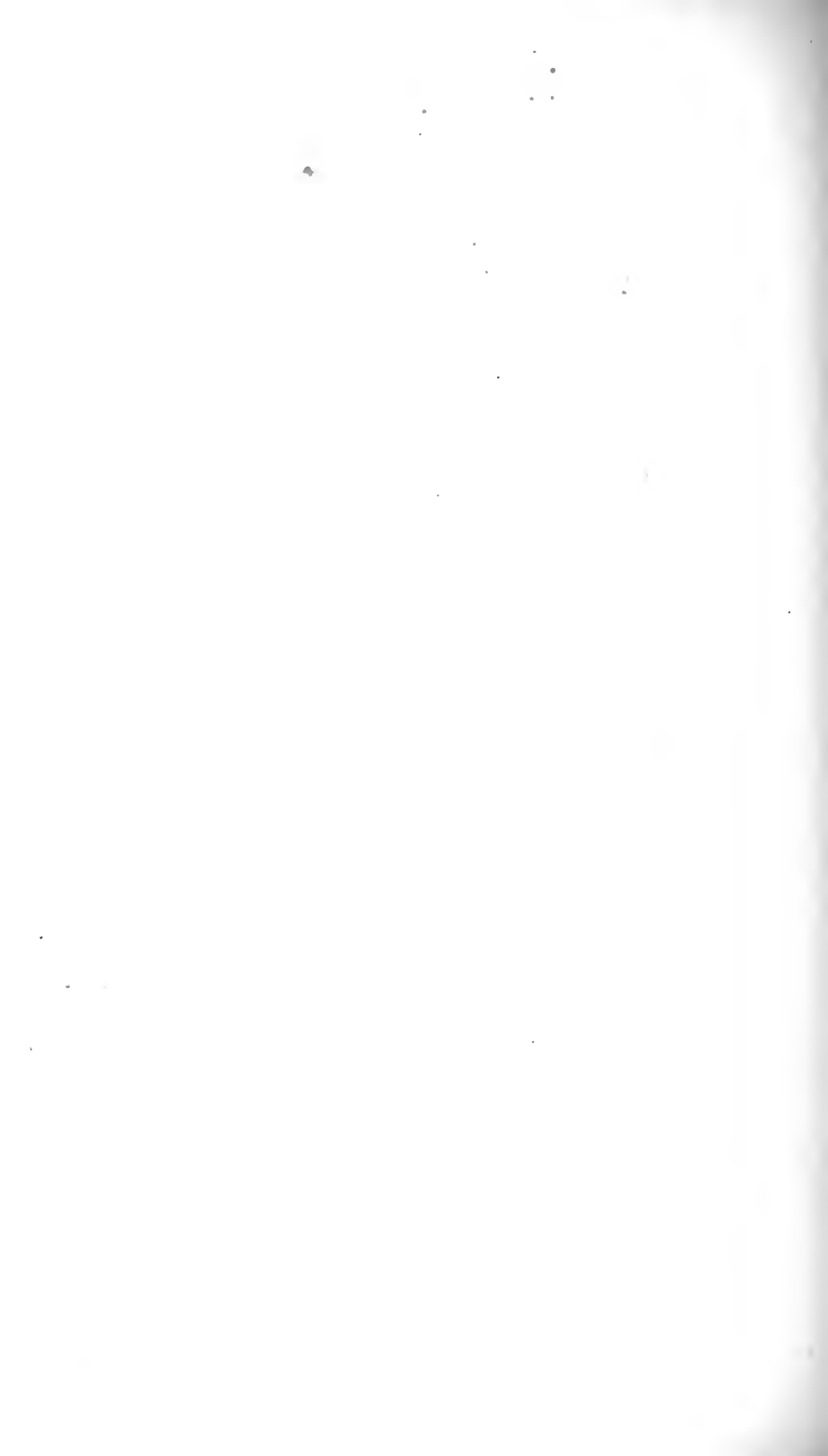
These hollow bricks have never been used in this country: they are, however, used in France, where they are of a different form from the English, being about five inches

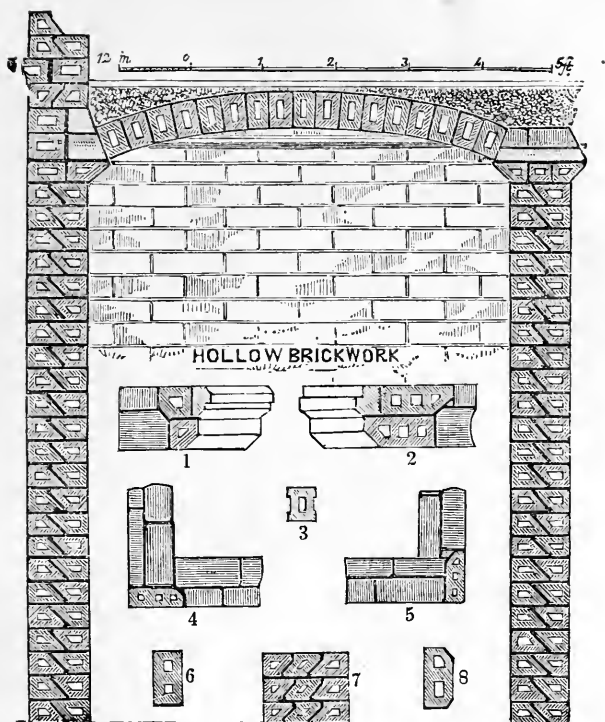




THE MODEL COTTAGE

[See p. 186.]





by six, with square holes through them. They are stronger than the English brick, by about one third.

JOSEPH E. HOLMES, Esq. director of the machine department in the New York Worlds Fair, in connection with Mr. F. B. TAYLOR, has invented a machine for the manufacture of hollow brick, which will undoubtedly be successful.

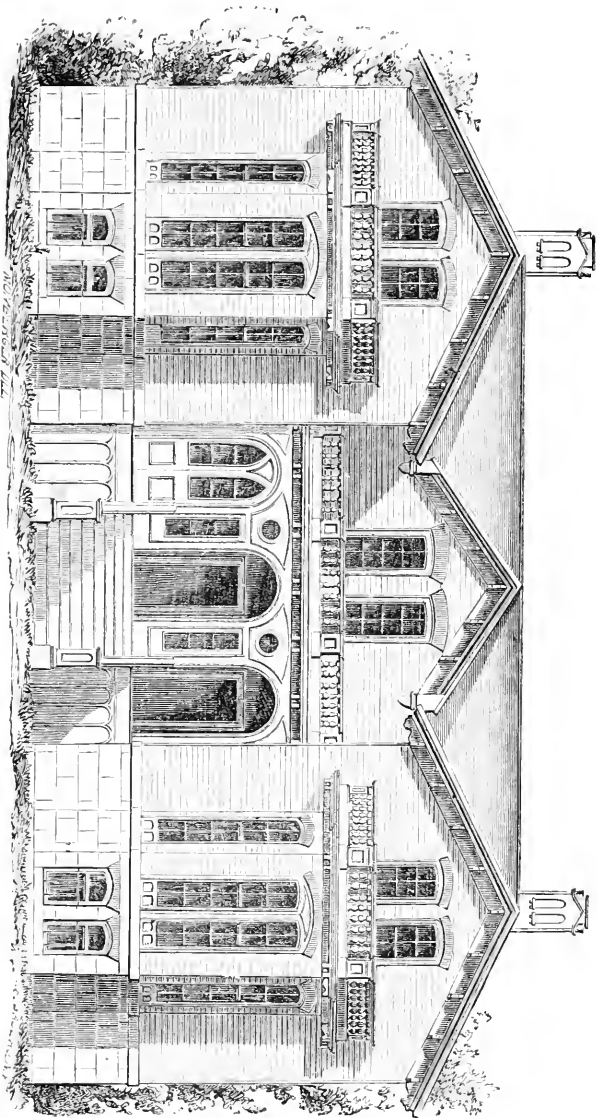
The frequent use of hollow brick in this country is not far distant.

The process of the manufacture of hollow brick, would, I doubt not, be quite interesting to my readers, but the limits of the work will not permit me to give it.

I hope that the day is far distant when PRINCE ALBERT'S Model Cottages will be thought an appropriate residence for an American laborer.

The room is too confined, the size is too small for our people.

PRINCE ALBERT deserves great credit for aiding in bringing to the English laborer such cottages; they are by far more comfortable than those which the bulk of their laborers enjoy. But with us, the case is different; nine-tenths of our laborers and Mechanics live in far better residences than the "Model Cottage." To us, PRINCE ALBERT'S Model House possesses no value—except as the ideas advanced by its peculiar mode of construction.



RURAL COTTAGE.

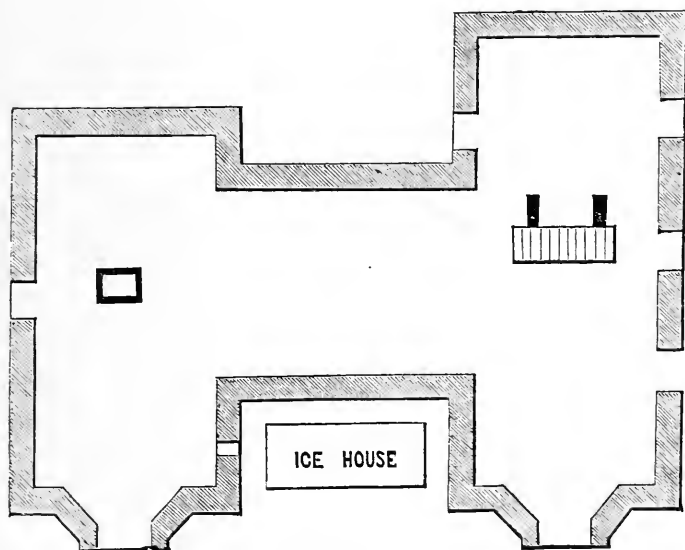
[See p. 180.]



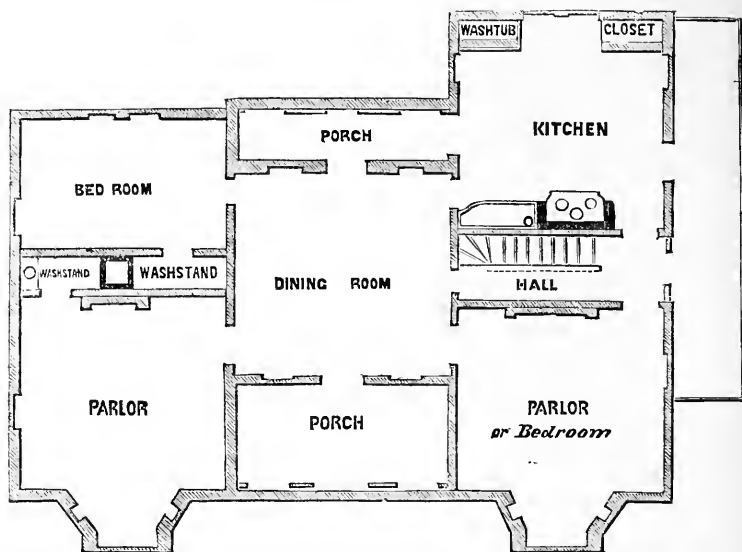
## CHAPTER XII.

## RURAL COTTAGE.

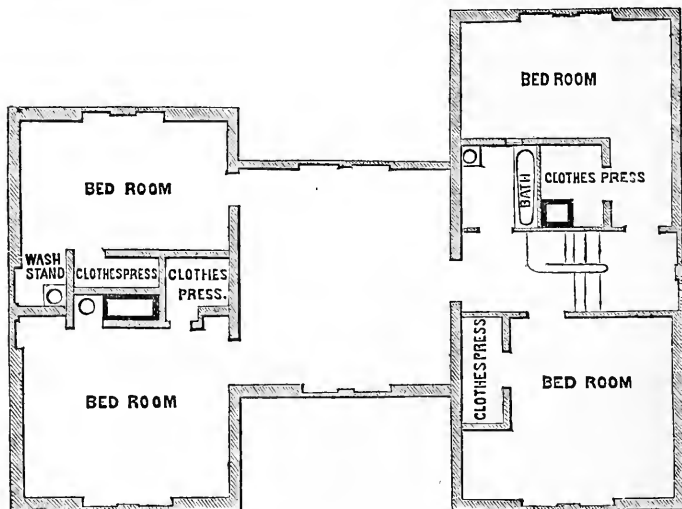
THE ABOVE is a representation of the residence of ALEXANDER DAVIS, Esq. Stuyvesant, New York. The architect is ROBERT WARRY, Esq. It is situated on a bank above the railroad, and commands a pleasant though not very extensive view of the Hudson River. The house wears an air of convenience, gentility and comfort.



BASEMENT PLAN.



PLAN OF THE FIRST FLOOR.



PLAN OF THE SECOND FLOOR.



The cellar or basement, is all in one room, and that the whole size of the house, with two brick pillars, supporting the centre of a timber each, on which a part of the floor timbers rest.

The thickness of the foundation walls is two feet, except the front above ground, which is brick twenty inches thick. The thickness of the first and second story walls is sixteen inches, with four-inch opening, or hollow wall, and plastered on the brick. In the Chapter on "MODEL COTTAGES," and in the Chapter on "THE VARIOUS PARTS," the advantages of building walls with hollow bricks, are discussed. It will be observed that all the advantages of the hollow brick, are gained by building the walls apart, and plastering on the brick. The walls are impervious to dampness.

There is a cistern in the rear, as also a well near the kitchen door. The same pump in the sink, supplies the water from either. The design is, that the house be warmed by a heater, in the basement, although it may be heated by stoves.

The house fronts on the Hudson River, nearly west. It is drained by pipes running under the door-sill, through the cellar into cess-pools.

The cost of this house was six thousand dollars,—built of brick; but if it were made of wood, it would lessen the cost very materially. The cellar is very large—larger than most families desire.

The expense of building could be much cheapened in the construction of the foundation and cellar. An additional closet or two, would, perhaps, add to its convenience. The house is painted yellow, which harmonizes with the surrounding objects, giving it a neat, tasty appearance. Houses might be built of wood after this design, retaining all its convenient arrangement, for from \$3,500 to \$5,000, varying according to the place in which it was built—the price of materials and labor being different in different localities.

## CHAPTER XIII.

## OCTAGON COTTAGE.

THE COTTAGE of Octagon Form possesses some valuable points in the economical arrangement of room.

The engraving of "Octagon Cottage" is a perspective view of the residence of O. S. FOWLER, Esq., the Phrenologist. The design is by Mr. FOWLER himself.

## PLAN OF BASEMENT.

There are sixty rooms in the house. The arrangement is novel and peculiar. All the cellar is above ground, except the holes *C*, *L*, and *M*.

*M* is the milk apartment.

*A P*, is the room for fruits and vegetables.

*K S*, is the kitchen-stove apartment; in its corner is a closet *C*, and stove-pipe hole *S*.

*W R*, is the wash-room, in one corner of which is a cistern.

*C* is the cistern.

*K* is the kitchen.

At the left of the cistern is the dark cellar *C*.

*L* is the lumber-room.

*S T*, is the stove-room.

*F E*, front entrance; *R E*, rear entrance.

*R R*, receiving-room.

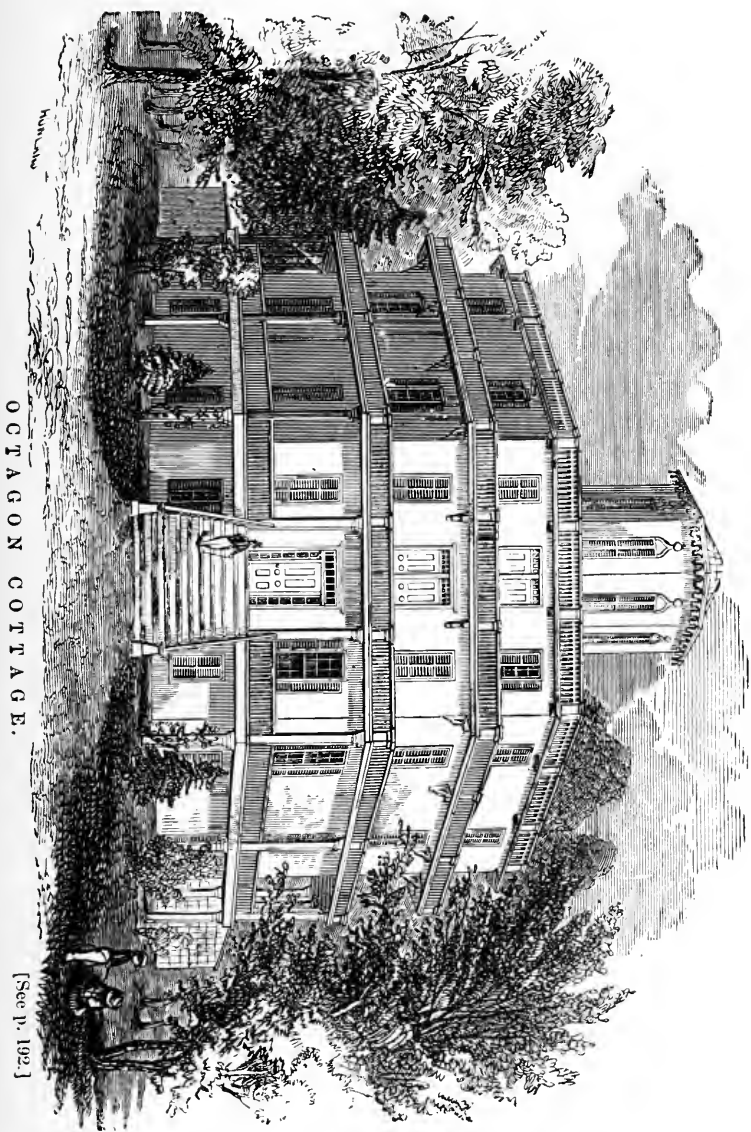
*F*, furnace.

*G*, gas apparatus.

*R*, range; *C L*, clothes-press; *P*, pantry.

*W D*, workmen's dining-room.

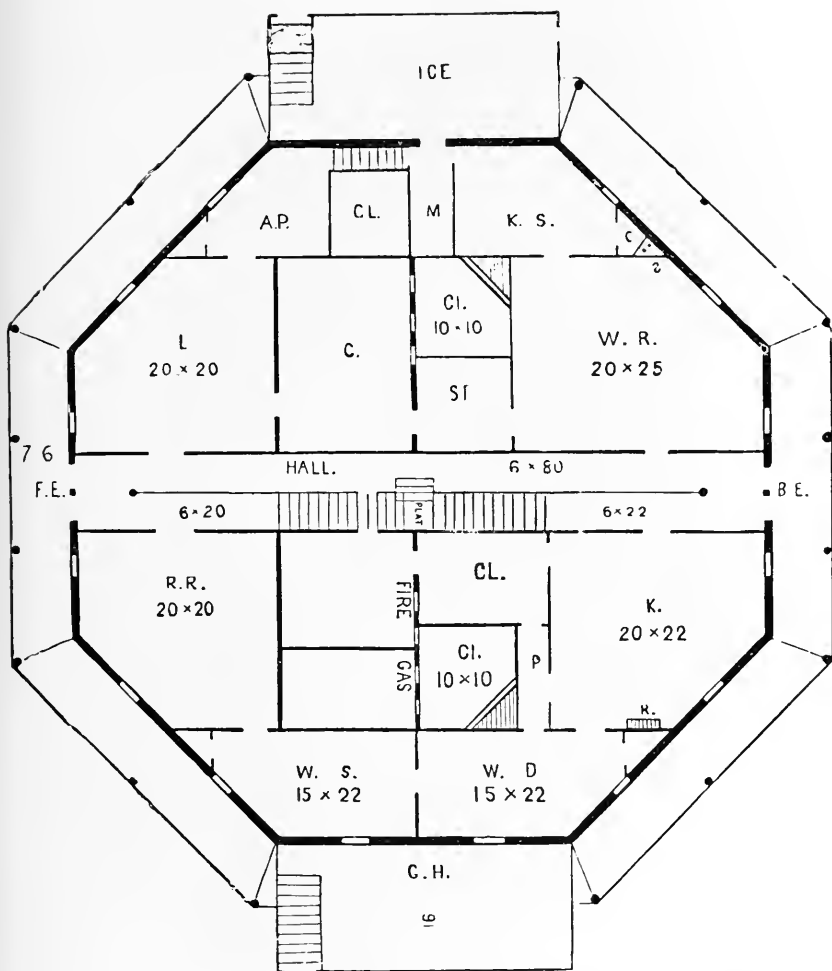
*V S*, winter sitting-room.



OCTAGON COTTAGE.

[See p. 192.]

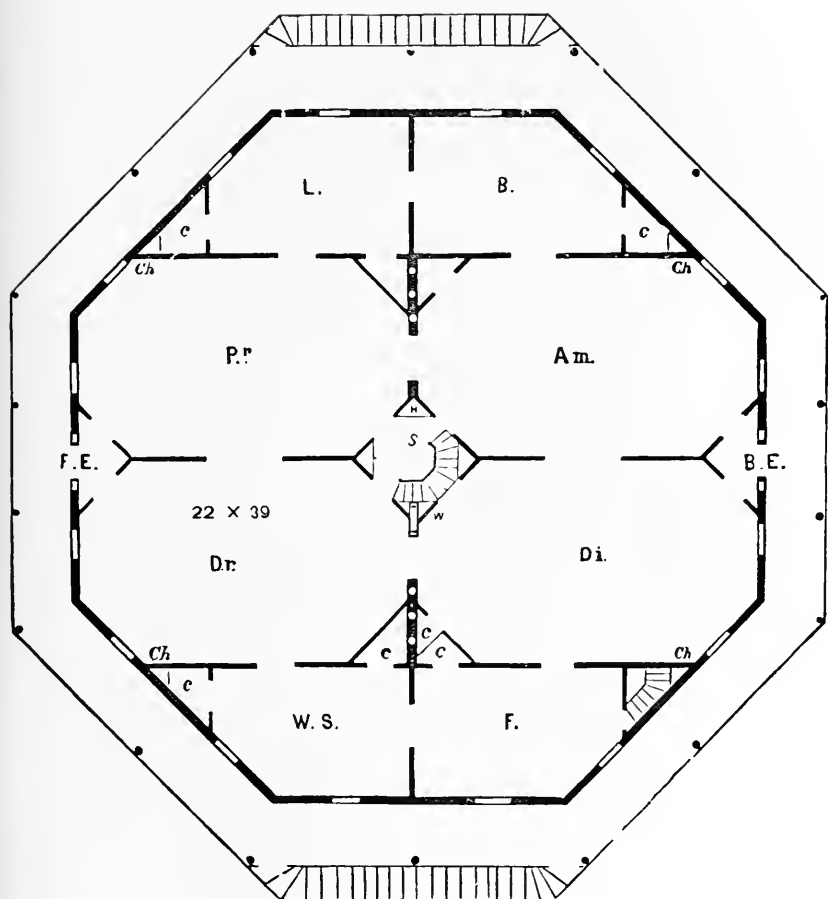




PLAN OF BASEMENT OF OCTAGON COTTAGE.

[See p. 192.]





PLAN OF PRINCIPAL STORY OF OCTAGON COTTAGE.

[See p. 193.]





## PLAN OF PRINCIPAL STORY.

The main story is surrounded with a portico, which makes it very desirable as a southern residence, where shade is at once a necessity and a luxury. The portico is a covered circle (around the house) of three hundred feet.

*F E*, front entrance ; *R E*, rear entrance.

*S*, stairway.

*W*, dumb waiter.

*D r*, drawing-room.

*D i*, dining-room.

*P r*, parlor.

*Am.* Amusement-room.

*W S*, winter sitting-room.

*L*, library.

*B*, bed-room.

*F*, sleeping-room.

"There are two stories to the ice house—the upper one for ice—the lower, a room kept, by the ice and its dripping, as a preservatory for fruit, butter, eggs, &c. The melting ice keeps this room at a temperature just above the freezing point, and surrounded by stifled and cold air, so that its preserving powers are remarkable."

The ice-water is gathered at the door, under which it runs through a lead pipe, bent up like a new moon, which allows water to pass *out*, but prevents air.

It passes into the cellar, *C*, *L*, and the milk closet *M*, which also has two stories, the lower for preserves, and the top for milk, having two floors, which admits the cold air up into the milk room yet, prevents dirt from descending by the lower.

The walls are of gravel-concrete—slate, stones, and gravel mixed with lime of the coarsest kind, such as farmers put upon their land for  $4\frac{1}{2}$  cents per bushel. To eight wheel barrow loads of lime were added from sixteen to eighteen barrows of sand, and then from sixty to eighty barrows of coarse rubble stone.

This gravel-concrete becomes harder the longer it is exposed to the weather. It may be desirable to put some stone within the wall, so as to keep it in its place, until it becomes thoroughly hard.

The ground story walls are nine feet high, and eighteen inches thick; those of the second story are fourteen feet high and sixteen inches thick; those of the third story twelve feet high, and twelve inches thick. The walls are anchored and plastered outside and in. The cost of the brick is ten times that of this gravel-concrete. Mr. FOWLER, in his work, "Homes For All," urges the adoption of octagon houses, built with walls of gravel-concrete as the best for "all." He considers that "*masons' wages and the cost of the brick are saved.*"

The octagon form of the house makes a far more economical and convenient arrangement of room, than the square.

Some houses in New Jersey, near New York city, are built of a concrete which is much similar to Mr. FOWLER'S. The foundation being laid, the walls of the building were formed thus: a strip of board about five inches wide and one thick is laid on the foundation wall. On this strip another strip of the same width is nailed, but projects over the first strip half an inch; the third strip is nailed on the second strip, and projects over the opposite side, about one half an inch; these strips are laid on projecting over each other alternately, the outside half an inch, and the inside half an inch. In this way the whole wall is laid, presenting, when complete, a series of grooves running the whole length of the walls, an inch apart. These walls are plastered up, outside and in, with a sort of stucco or concrete, which hardens with age, and becomes as solid as stone. It is less impervious to the rain than brick, and is a very cheap mode of building. The plan of the house may be either square or octagon, as shall be desired.

The cost of Mr. FOWLER'S house was about ten thousand dollars. The octagon form is adapted to smaller cottages; than Mr. FOWLER'S, to school houses, and public buildings

## CHAPTER XIV.

## DRAINAGE.

DRAINAGE is an important matter in the building of cottages, as on it depends the health and convenience of the occupants.

In suburban residences, almost invariably, the water is supplied by "water-works," from the adjoining city, and the refuse water is taken off by drains into the sewers of the street. Water-closets, baths and wash-basins are a part of the fixtures of the house, and in the basement a boiler is so connected with the range, that hot water is forced through pipes to any desired place in the building.

It is estimated that the inhabitants of towns will consume on an average twenty gallons of water for each person. This quantity would be sufficient to allow also for an ordinary proportion of manufacturing operations, for the supply of public buildings, and for the extinction of fires.

When baths are used, not less than fifty-four gallons of water should be provided for the ablution of each person.

The necessity for a constant supply of pure water, great as it is in all buildings, is still more important in supplying those of which the demand is of a variable character. In certain seasons, when the occasion for the repeated bathing of persons and cleansing of apartments is greatest, these duties require a much larger quantity of water than will suffice at other periods; and this demand of course increases in the same ratio with the number of persons to be supplied. In prisons, asylums, and public buildings, the quantity of water required varies considerably from time to time, and all methods of supply short of constant service, and all provisions for storage fail, in one way or another, in securing the constant and unlimited command of fresh and pure

water. These house-tanks, cisterns, and reservoirs, how ever capacious and well-designed, serve to receive only limited quantities, and if these be ample for all purposes, it follows that if the consumption be lessened, the greater quantity of water will remain in a stagnant condition, to be added to, but not replaced, by the next delivery from the main. The lower body of water in the cistern will thus remain slightly changed, and stirred up only, and in this way a low bed of impure water, surcharged and rendered heavy with deposited matter, gradually accumulates, suffering a slow diminution by the proportion drawn off for immediate use. *Pure or fresh water* is by this arrangement put altogether out of the question.

In cases where the constant supply of water cannot be obtained, and in consequence it becomes necessary to provide cisterns for buildings, they should be so constructed and furnished as to combine the operation of filtering with the purpose of storing the water. For this purpose, the best form of cisterns will be that of which the bed inclines downwards, so that the discharge-pipe may be inserted at the lowest point, and the water always drained from that part of the cistern. The material used being commonly slate, the bottom may still be formed in a single slab for house cisterns, (so as to avoid extra joints,) declining in both directions. The filtering media, consisting of beds of sand and gravel, of different degrees of fineness, will be arranged in horizontal layers, excepting the lower one, which will lie in the bottom of the cistern, and be dressed to a level on its upper surface. The head of the discharge-pipe should be protected with a fine wire-gauze cap, to prevent the gravel washing in the pipe. Below this pipe another cistern for the filtered water should be provided of proportionate capacity; and if the process be too tedious to admit of the filtration of all the water used, that for inferior purposes may be drawn from a pipe entering the cisterns just above the filtering-beds.

The superior quality of rain-water in respect to its softness, as compared with water from all other sources, renders it exceedingly desirable, in an economical view, that all the supply requisite from this source should be carefully collected and preserved. In towns and cities, this water is commonly wasted, or, at least, allowed to subserve the inferior purpose of assisting the flow of drainage. Yet the quantity which might, by efficient arrangements, be commanded of this superior water, is by no means insignificant. The roof of a house of average dimensions of twenty feet square, presenting a plane surface of four hundred square feet, receives at least eight hundred cubic feet of rain-water annually, or about four thousand eight hundred gallons. If well-constructed and capacious gutters are provided, this quantity may be collected with little loss from evaporation, and will form a reserve stock for such special household purposes as it is peculiarly adapted for. This quantity should be immediately received in a filtering tank, and the best available method be adopted of purifying it from the carbonaceous matters with which it becomes saturated in passing through a smoky atmosphere and flowing over roof-surfaces covered with a deposit of similar impurity. An economical and well-devised apparatus for effecting this purpose, and applicable to private buildings of all classes, is a desideratum yet wanting in the economical supply of water.

If rain-water be not collected for household cleansing purposes, it should at least be made as efficient as possible for scouring the house-drains. In many houses the rain-water is conducted into a cistern, the lower part of which should be formed like an inverted cone, and fitted with a conical valve at the head of a pipe, discharging into the house-drain. This conical valve is to be attached to a vertical chain above it, and connected with the short end of a lever, to the other arm of which a cord or chain is fixed, and by which the valve may be occasionally removed from its seat and the water discharged from the cistern into the drain-

pipe below the valve, so as to prevent the cistern overflowing, in case the water accumulates faster than it is discharged; the lower end of the waste-pipe being trapped, to prevent the effluvia in the drain-pipe passing into the cistern.

One of the most important of the occasional services for which a supply of water is required for application to buildings is the extinction of accidental fires. For extensive buildings, tanks have been adopted, in which a considerable quantity may be stored and ready for instant application for this purpose. This arrangement is, however, scarcely applicable for private buildings; and, where it is employed, the quantity commanded is of course limited, and can never be safely trusted to as affording an adequate supply for extinguishing the fire. In this application of water, again, the system of constant service offers great advantages. Thus, if the mains are always kept filled, an adequate supply is at all times at hand in every direction, and the grievous losses and dangers incurred by delay in obtaining water on these occasions are avoided.

The combination of high service with constant service in the supply of water, also affords the means of instantly applying jets of water upon the fire until the fire or pumping engines arrive. These jets are thus available as substitutes for the engines, and the experiments made to ascertain the height to which a jet of water will rise from the main and service-pipes under a fixed pressure, have shown considerable facility in applying jets for this purpose and a corresponding efficiency in their actions. The practical limit to this mode of delivery appears to arise from the extent of supply required, the economy of the use of jets depending upon the amount of pressure that can be obtained, and the small number of jets which will suffice for the extinction of the fire. The available power in this instance is found to decrease in proportion to the extent to which it is employed, and the loss by friction in the leather hose reduces the delivery, and, consequently, the height or force of the jet

2½ per cent. for every 40 lineal feet of hose through which the water passes.

The following experiments show the action of water through the pipes :

The first experiment was made over an extent of 800 yards of 7-inch main, which were connected with 500 yards of 9-inch; this length being joined to 200 yards of 12-inch, continued by 550 yards of 15-inch main to the great main—5,500 yards distant. The height to which the water was thrown from 2½-inch stand-pipes, with 40 feet of hose and a 7⁄8-inch jet, were as follows :—

With 1 stand-pipe the water rose	-	-	-	50 feet.
“ 2 “ “ “	-	-	-	45 “
“ 3 “ “ “	-	-	-	40 “
“ 4 “ “ “	-	-	-	35 “
“ 5 “ “ “	-	-	-	30 “
“ 6 “ “ “	-	-	-	27 “

When all the fire-plugs on the main were closed, except the first and one 2½-inch stand-pipe, and 160 feet of hose with a 7⁄8-inch jet applied, the water rose to a height of 40 feet.

The quantity of water delivered from the same (7-inch) main through one stand-pipe, and different length of hose, was as follows :—

With 40 feet of hose	96 gallons in 59 seconds.
“ 80 “	112 “ “ 65 “
“ 160 “	116 “ “ 70 “
“ 40 “	and 2½-inch jet, 118 feet in 27 seconds.

The second experiment was made with a 9-inch main 1,400 yards in length, joined to a 15-inch main of 1000 yards in length, and at a distance of 6,650 yards from the works. The stand-pipes used were 2½-inch, the hose 40 feet long, and the jet 7⁄8-inch, as before.

With 1 stand-pipe the water rose	-	-	-	60 feet.
“ 2 “ “ “	-	-	-	60 “
“ 4 “ “ “	-	-	-	45 “
“ 6 “ “ “	-	-	-	40 “

The quantity delivered with the same pipes, length of hose and size of jet, being

With 1 stand-pipe	114 gallons in	-	-	-	-	64 seconds.
" 4	" 115	"	-	-	-	75 "
" 6	" 112	"	-	-	-	78 "

These experiments, with the two sizes of main-pipe, will indicate the rate at which the quantity is diminished by the friction of the water in smaller pipes, a result confirmed by another experiment made with the addition of 200 yards of 4-inch service and 200 yards of 5-inch pipe to the 9-inch main, last referred to. The hose, 40 feet long, and the jets  $\frac{7}{8}$ -inch as before.

With 2½-inch stand-pipe fixed on the 4-inch service near the 5-inch pipe, the water rose	-	-	-	-	40 feet.
" 2	"	"	"	"	31 "
" 1	"	"	"	fixed at the end of service or	
				200 yards from 5½-inch pipe, the water rose	34 feet.
" 2	"	-	-	-	23 "

The quantity delivered in each of the last four cases being respectively as follows :—

112 gallons in	-	-	-	-	-	82 seconds.
117 "	-	-	-	-	-	103 "
112 "	-	-	-	-	-	90 "
114 "	-	-	-	-	-	118 "

The piping for the conveyance of water to buildings has to be graduated in capacity according to the quantity required, in the same way that the mains and service-pipes are proportioned to the building or buildings intended to be served.

In some cases, in order to provide very fine cold water to private houses, an iron cistern, to hold not less than 20 gallons, is sunk eight or ten feet below the bottom of the cellar, and supplied with water through a small lead pipe entering it at the top, while the water is drawn off for use through another smaller pipe, inserted a few inches above the bottom of the cistern. It would appear, however, that the cleansing of cisterns thus situated must be a somewhat troublesome duty, and the means of regular access to a



cistern so deeply sunk in the ground must involve a considerable additional expense in construction.

The several operations carried on within a building devoted to manufacturing purposes should afford the data upon which to determine the extent of drainage required ; but the most ready way of estimating the amount of refuse waters produced, will be reached by assuming this to equal the supply of water rendered to the building. The application of the same rule to domestic buildings or dwellings, admits of a more exact calculation as to the capacity of drains required ; but these must all alike be governed by the principle that ample capacity for immediate discharge is to be sought with due regard to the fact that all passages for the conveyance of liquid or semi-liquid matters are efficient in proportion to the narrowness of the surface over which these matters are required to flow. This is one of the most important results which recent inquiries have established. Sewers and drains were formerly devised with the single object of making them *large enough*, by which it was supposed that their full efficiency was secured. But sluggishness of action is now recognized as the certain consequence of excess of surface equally as of deficiency of declination. A small stream of liquid matter extended over a wide surface, and reduced in depth in proportion to this width, suffers retardation from this circumstance as well as from a want of declivity in the current. Hence a drain which is disproportionally large in comparison to the amount of drainage, becomes an inoperative apparatus, by reason of its undue dimensions ; while if the same amount of drainage is concentrated within a more limited channel, a greater rapidity is produced, and every addition to the contents of the drain aids by the full force of its gravity in propelling the entire quantity forward to the point of discharge.

There are four conditions which are to be regarded as indispensable in the construction of all drains, from all buildings whatsoever. These conditions are—First. That the

entire length of drain is to be constructed and maintained with *sufficient declivity* towards the discharge into the sewer to enable the average proportion and quantity of liquid and solid matters committed to it to maintain a *constant and uninterrupted motion*, so that stagnation shall never occur. Second. That the entire length of drain is to be constructed and maintained in a condition of *complete impermeability*, so that no portion of the matters put into it shall escape from it. Third. That the head of the drain shall be so efficiently trapped that no gaseous or volatile properties or products can possibly arise from its contents. And, fourth. That the lower extremity of the drain, or the point of its communication with the sewer, shall be so properly, completely and durably formed, that no interruption to the flow of the drainage or escape shall there take place, and that no facility shall be offered for the upward progress of the sewage in case the sewer becomes surcharged, and thus tends to produce such an effect.

These conditions appear so simple in their statement, that we are disposed to regard them as self-evident necessities; yet an acquaintance with the details of house-drainage, as commonly regulated, reveals the fact that they have been generally neglected, and that at the best the attention they have received has been most unwisely crippled by considerations of cheapness in first cost at the expense of permanent economy and usefulness. Thus we know that house-drains are frequently laid with very imperfect fall—not sufficient, indeed, to propel the matters sent into them, except with the aid of gushes of drainage-water; that they are often composed of defective and carelessly-built brickwork, with wide joints of sandy mortar; that the head of the drain is commonly untrapped, and that the entire formation is badly designed and defectively executed. We will endeavor to show the arrangements by which the efficient action of the separate drains of houses and other buildings is most likely to be secured.

The utmost practicable declivity being obtained in the direction of the drain, the efficiency of its action will be further much controlled by the construction adopted and the kind of surface presented to the sewage. Any roughness or irregularity in this surface will of course impede the passage of the sewage, and hence arises the necessity for the greatest care in the construction, whatever the material and kind of formation. The first step in the arrangement is to collect the whole of the drainage to one point—the head of the intended draining apparatus—and the determination of this point requires a due consideration of its relation to the other extremity of the drain at which the discharge into the sewer is to take place. In buildings of great extent this will sometimes involve a good deal of arrangement, and it will, perhaps, become desirable to divide the entire drainage into two or more points of delivery, and conduct it in so many separate drains to the receiving sewer. The length of each drain being thus reduced to a manageable extent, the necessary fall will be more readily commanded, and the efficiency of the system secured.

All main sewers should be formed with concave bottoms, to allow the water, however small in quantity, passing along with solid matter, to act with the utmost possible effect ; and they should be evenly built, not only that any solid matter may be unobstructed, but that the force of the running water may be as little lessened by friction and distribution as possible. They should have arched tops, and be of sufficient height and width to allow men to pass along to repair or cleanse them.

They should have a *fall* of not less than  $1\frac{1}{2}$ -inch in every 100 feet in length, and more than this in all cases where the flow of water is variable.

They should have a constant flow of water through them, or powerful flushes at stated intervals.

Means should be provided for their complete ventilation; that is, fresh air should enter them from a low level, and

the heated and foul air should pass away at as high a level as possible.

All *soilage drains* are found to be of sufficient dimensions, and the soil and water find ample room to pass along, in a tube equal in capacity to a cylinder of six inches in diameter.

They should have a fall of not less than one-half an inch in every one hundred feet, under favorable circumstances; and when the water is likely to be small in quantity, as much as two to three inches.

They should be made water-tight, that the liquid portion of the soilage may not escape and leave the solid matters in the drain.

They should have a constant flow of water through them, or water in continuous flushes on the lower levels, to carry the soilage onward, and to prevent any solid matter from being deposited within them.

To prevent the foul air generated in or returning by the drains, the waste-ways should be double trapped by a well-trap at a sink where the waste water enters, and by a well-trap short of the inlet to the drain.

All drains should be so constructed as to admit of being opened for the purpose of cleansing, without breaking them, and of the displaced portion being afterwards replaced.

The average quantity of water which falls on a square yard of surface, in this country, is about 125 gallons, which for a building containing 50 square yards of roof, give 6,250 gallons.

The best position for a water closet in any building, is that in which all the waste water shall be made the best use of in scouring the contents directly through the pan of the closet, and propelling them forward through the private drain into the common sewer. And since the matters discharged into the closet will be—if the house-drain is reserved for its proper use—more solid and less readily conveyed than the other sewage matters; it will, moreover, be desirable to place the closet as near as possible to the point at

which the drain discharges into the sewer. The velocity and force of the liquid sewage are increased to the lower or sewer end of the drain, and its effect is thus augmented in scouring away the contributions of the closet. But if this preferable position cannot be commanded for the closet, it must at any rate be so situated with regard to the head of the drain and the inlet for the liquid sewage, that these shall be behind or above it. When the closet and the house-sink are near to each other, the water from the latter may be conducted directly into the trap or basin of the closet, and thus secure at once a rapid discharge of its contents and a constant supply of liquid to preserve its action and efficiency.

The rudest form of domestic accommodation or open privy over a cesspool is a contrivance which deserves notice only on account of its several imperfections, and which will, it may be hoped, be soon reckoned among the obsolete mistakes of our forefathers. These cesspools are sometimes mere pits or holes excavated in the ground, and the contents of course rapidly permeate the surrounding soil; by which process pits of this kind frequently are found to drain themselves, the perviousness of the material permitting the escape of the sewage, so that little accumulation takes place within the pit itself until the whole neighborhood becomes fully saturated with the drainage, which will then ooze through and appear upon the surface, or find its way through some defective foundation, and poison the basement of an adjoining building. Constructed cesspools formed with brickwork of substantial quality will prevent this saturation in proportion as their walls are carefully and imperviously built. The matters daily discharged into these depositories accumulate, and their decomposition is constantly proceeding and engendering gases of the most noisome and pestilential kind. The open privy formed over a pit of this description affords an outlet for the escape of these gases which are thus regularly supplied to the building above or adjacent to the closet. If a trap or water-basin and pan be applied to this

privy, so that the pan dips into the trap, the escape of effluvia may be prevented so long as the trap is kept supplied with water. The supply of water for this purpose will, however, considerably augment the bulk of the sewage, and necessitate cleansing much more frequently than otherwise, unless some defect in the joints of the work afford a passage for the liquid matters into the surrounding strata, or a communication be afforded with a drain. In this latter case of combination of a cesspool with a drain, a waste-pipe may be laid from the former into the latter, so that the contents of the cesspool shall always be maintained at the same quantity and depth; the trap may then be dispensed with by attaching a vertical pipe to the lower part of the pan, so that this pipe shall dip into the sewage, and being thus constantly kept below its surface, no gas can pass upward through the pipe. The cost of the pan or basin and pipe required for this contrivance, if of stone-ware, is small, and its advantages in preventing the escape of effluvia are obvious.

The great importance, however, of avoiding all sources of unwholesome and offensive effluvia, and of preserving the foundations of the buildings and the substrata of the soil of a town in a dry and clean condition, creates a severe necessity for relinquishing cesspools, and all *receptacles* for sewage, within or connected with all buildings and places whatsoever, except those to which it is conducted for the purposes of collection and treatment. *The sole purpose of all house apparatus of water closets, sinks, and drains, and of all public constructions of branch or tributary sewers, and main sewers, should be that of affording a passage for the conveyance of the refuse waters and other matters produced in a town. This conveyance should be immediate, every particle committed to the entire ramification of passages being preserved in ceaseless motion until it arrives at the final collecting-place.* In the country or in villages, these objections to cesspools have less force.

Discarding cesspools upon these grounds, we are at the

same time led to the principle which should govern the whole of the details of house-draining apparatus, which should be so arranged and combined as to afford the fewest possible inlets for effluvia from the matters committed to the drains, and to make the total of the liquid refuse useful in advancing the current within the drains. The position of the water closet being determined, it becomes desirable to select the most economical and efficient construction for it, and for the apparatus connected with it.

The head of the drain, and every inlet to it, requires to be fitted with a trap to prevent the escape of effluvia, and this will equally form an indispensable part of the closet apparatus. The perfect action of the trap will demand a means of supplying water on each use of the closet, and although all possible advantage should be taken of the house sewage water in promoting the action of the drains, a separate and constantly-commanded source should be provided for this purpose. If the supply of water to the house or building be rendered upon the constant-service system, a mere tap will be sufficient to afford the means of discharging a volume of water through the trap of the closet. If the water be supplied upon the intermittent system, a cistern or reservoir of some kind, provided for the house supply, must be made to communicate with the pan of the closet by a pipe with a valve and apparatus for working it. For general use, it is especially desirable that economy and simplicity be combined in the whole of the apparatus of the closet. Delicacy of adjustment, requiring a complicated arrangement of parts, and a corresponding costliness of construction and repairs, and carefulness in management, is inadmissible in a design adapted for general adoption; and combinations of levers and cranks, liable to accidental derangement and injury by roughness of treatment, are therefore to be avoided as much as possible. The position of the cistern in relation to the closet will affect, in some degree, the force and efficiency of the volume of water dis-

charged on each occasion; and, if the supply of water to the building be constant, the service-pipe should be so conducted over the closet that the tap can be conveniently placed for admitting the required quantity to the pan. If the supply is obtained from a house-cistern, this must, of course, be placed above the pan, and at such elevation that the water may acquire a sufficient impetus to flow with rapidity.

Glazed stoneware basins or pans, with syphon traps combined, before referred to, are very economical and effective for general purposes. These are made in several forms; viz: with the pan and trap in one piece, and adapted to communicate either with a vertical or a horizontal drain, with a separate trap, having a screwed socket on the head, in which the lower part of the pan is received, being formed with a collar and screwed end; or as a somewhat more complicated arrangement, consisting of a trap with a flanged head, and a separate dip-pipe, having a projecting flange about its mid-length, and a spreading mouth above, into which the lower part of the pan is fitted with cement. The dip-pipe, extending downwards into the trap, below the level at which its contents flow out, is secured to the head of the trap by bolts, passing through the holes in the flanges. The reason for making the pan separate from the dip-pipe, would appear to arise from a difficulty in forming them together with the wide projecting flange, so as to give sufficient steadiness to the pan above.

Self-acting valves or traps are constructed of stoneware or metal; and the valves being hung at a slight inclination, and well filled with a rim on the meeting surface, they remain closed against any retrograde movement of the sewerage or gases, but are readily opened by a slight force of water in the outward direction of the drain. Sink traps are also formed of either substance, with perforated heads or covers, and syphon bends below, which, remaining filled with the drainage water, prevent the escape of any effluvia from the drain into which they give access.



Although complexity of parts is to be avoided in water-closets intended for use, in the greater number of dwellings, some of the more complete forms of apparatus adapted for self-action, and which necessarily comprise considerable detail of arrangement, are preferable in superior buildings, in which close economy of construction is not a first condition, and regular care and attention can be secured for the action of the apparatus employed. In some of these closets, the valve which opens and closes the opening into the water pipe, is attached by a rod to a lever, which, by means of a cord or chain, is connected with the door of the closet, so that the opening of the door opens the valve, and thus discharges a quantity of water into the pan. In another form of apparatus, the pressure of the person on the seat produces a similar effect. One form of this closet is self-acting and doubly trapped, and designed to secure a supply and force of water, which shall always be efficient and uniform without waste. It is so contrived that no soil can remain in the basin after use, and an ample supply of water being secured in the basin so as to form a "water-lute" between that and the syphon-trap, the rising of smell is effectually prevented. The lower part of the pan dips into a water-pan or trap, which is hinged and maintained in a horizontal position, by a rolling balance-weight. The effect of pressure on the seat of the closet is to depress a lever and open a valve in the supply-box of the cistern, and thus pour a volume of water into the water-pan or trap, sufficient to throw it open, and thus afford a passage for the soil into the lower basin, which terminates in a syphon, and is also trapped with water. When the pressure is removed from the seat, the water-pan or upper trap is immediately brought back to a horizontal position by the rolling weight, and receives sufficient water before the closing of the valve to fill it, and thus effectually shut all communication with the lower basin.

## CHAPTER XV.

## RURAL HOMES.

IN THE choice of the situation for a villa residence, two classes of circumstances require to be taken into consideration: the one includes such as are absolute or permanent; and the other such as are accidental, or liable to vary from temporary causes. The permanent considerations include climate, elevation, surface, aspect, soil, water, and the sea; and the temporary or accidental circumstances are chiefly its locality, present state, prospective improvement, and the personal peculiarities of its intended possessor.

*Climate* is, perhaps, the most important of the permanent circumstances which require to be kept in view in fixing on the situation of a villa; because it is less subject to human improvement than any other. In every country of any extent, the climate differs in different parts of it, and the popular divisions may be stated to be the cold, the warm, and the moist. The last is unquestionably the least desirable; because it admits of least amendment by human means. The cold climate, provided it be dry, is often one of the healthiest, and it may always be improved by planting, to afford shelter, and by increasing the dryness of the soil by draining. The warm climate, if it be dry, is always agreeable; and if the heat be intense during summer, it can be readily moderated by the shade of trees. A wet climate can scarcely be improved; it must necessarily be unhealthy, compared with a dry one, on account of the moisture with which the atmosphere is always charged; and it precludes the exercise of the greatest of rural improvements—the surrounding the house with plantations.

*Elevation* is the next most important circumstance to climate, although some may assign the second place to the

character of the surface. The great advantage of elevation is, that it gives a command of prospect, without which, a villa may be beautiful, picturesque, or romantic; but it can never be dignified or grand, and scarcely even elegant or graceful. The term elevation must always be considered as relative; and not to be determined by measurement. In a flat country, a knoll of one hundred feet in height, by raising the ground floor of the house above the level of the tops of the highest trees in the surrounding plain, will allow the eye to range over an extensive distance; to catch a view, in all probability, of some river or stream; and in a cultivated country, to command towns, villages, farms, and human dwellings. On the other hand, where the whole of the surface is hilly, he that prefers elevation, must fix on a hill somewhat higher than those by which it is surrounded, so as, at all events, to look over some of them. It is not necessary to dignity of effect and variety of prospect, that a house in a hilly country should enjoy such extensive views as a house on a plain, because in the former case, the variations of the surface produce that expression in the landscape, which in the flat country is unknown, and but faintly compensated for by the movement of the clouds, and other atmospherical changes.

In every country, however, there is a limitation to the height at which it is desirable to build dwelling houses; and this limitation is clearly determined by the growth of the principal timber trees of the country, indigenous or acclimated, and the ripening of the hardy fruits. In other words, it is determined by the capacities of the situation for gardening. Whenever a situation is so high that trees will not attain sufficient dimensions to shelter the house, or fruit not ripen on the garden walls, it ought to be abandoned, unless a better one cannot be found.

*The character* of the surface on which to build a villa, is the next consideration, and is also one of great importance. A surface may be uniformly hilly, or irregularly so; and

may consist of ridges and valleys, or of ridges on the sides of hills, rising above each other without valleys. The variety, in short, is so great, that it can scarcely be classified with sufficient distinctness. It is hardly possible, however, to conceive a hilly surface in which excellent situations may not be found for setting down a villa. Perhaps one of the most desirable is where a prominent knoll stands forward from a lengthened, irregular ridge; and where the latter has a valley with a river in front, and higher hills, rising one above another, behind. One of the worst is, perhaps, the steep, uniform side of a high hill, closely surrounded by other hills equally high and steep. On the whole, it may be observed, that though an irregular surface affords the greatest variety of excellent situations for building on, yet, at the same time, it is one in which the inexperienced are likely to commit the greatest errors; and one, also, respecting which it is more difficult to lay down general rules than any other.

*Aspect* is next in the order of importance. There are some considerations respecting aspect which apply to every country; and others to particular countries or districts of country only. Nothing in the architecture or appendages of a house can compensate for its being set down on the north side of a high hill or ridge, where it is precluded from partaking of the direct influence of the sun during three or four months of the year. In most countries, there is some point of the compass, from which rain and storms are more frequent than any other; and to set down a house in such a manner as to be exposed to these tempests is evidently injudicious. An aspect exposed to high wind is less objectionable than one exposed to driving rains; since shelter may be afforded from the former by trees, but not from the latter by any means.

*Soil and subsoil* are very generally reckoned among the primary considerations in the choice of a site for a villa; and they are undoubtedly the first, as far as respects the

value of the estate. But it must be recollected that the soil about a house can be totally changed by art, while the previously mentioned requisites of climate, elevation, surface and aspect, hardly admit even of improvement. Where these circumstances are favorable, the nature of the soil and subsoil, though of secondary importance, have yet still considerable influence, both in regard to health and enjoyment of the occupant, and the growth of the plantations. A soil which retains moisture on its surface, which is the case with most clays and loams with retentive bottoms, may be considered as the least healthy; and the one which admits of being walked on without wetting the feet, the soonest after a shower of rain, is the most so. For the present purpose, it will be sufficient to consider all soils as either clayey, sandy, gravelly or chalky; and all subsoils as either based on granite, argillaceous rock, sandstone, limestone, or chalk. Soils based on rocky subsoils, whatever may be the nature of the stone, may always be considered healthier than alluvial soils, sands or gravels. Soils laying on calcareous and sandstone rocks, are found to produce healthier surfaces than those on chalk or slatestone; and surfaces, also, which are much better adapted for cultivation and the growth of trees. In this respect, the subsoil is sometimes of more importance than the soil; for the latter, in general, can be improved by draining—and its susceptibility of this improvement varies materially, according to the nature of its subsoil. The most difficult subsoils to underdrain, are those composed of moist, retentive clays; and when, to this subsoil is joined a flat surface, the situation, as far as respects the enjoyment of walking in the open air, is one of the most hopeless kind. A bad subsoil is an effectual barrier to the thriving of timber trees; and, as these constitute the finest ornaments of every country seat, the importance of choosing a subsoil either naturally congenial to them, or capable of being rendered so by art, is sufficiently obvious. In an economical point of view, it

is always more desirable to choose a poor soil than a rich one, provided it be dry, for the immediate site of a house. Rich soils are better reserved for cultivation; and indeed, for the purpose of lawns and kept grounds, they only serve to increase the expense of mowing and weeding, by the luxurions growth of herbage. On the whole, therefore, the most important consideration, in respect to the soil of the site for a villa, is, that it should be dry, and placed on a subsoil favorable to the growth of trees.

*Water* is the remaining consideration; but it is one of very secondary importance. For all domestic purposes, it can be procured almost everywhere, by boring or sinking wells; and pieces of artificial water, where expense is not an object, may be supplied by machinery, from natural sources, at the distance of miles.

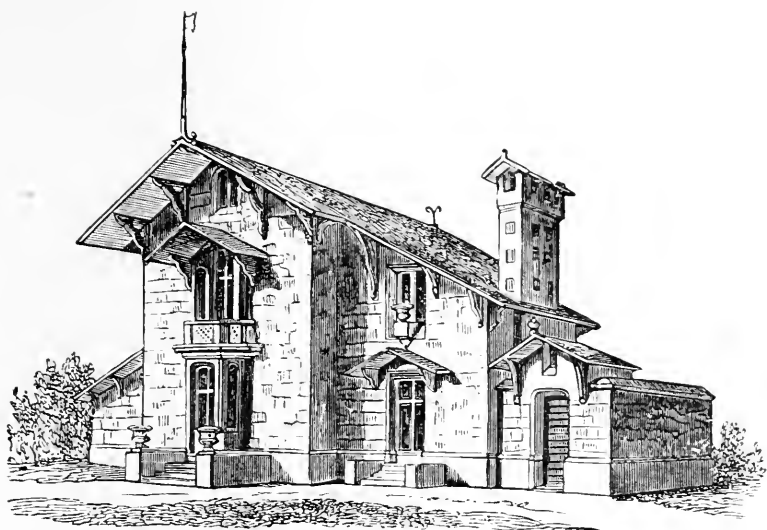
The word *VILLA* was originally used by the Romans to denote a farm house, with the offices requisite for the accommodation of a husbandman. Afterwards, when luxury increased, the term villa was applied to the country residence of the opulent Roman citizen; and it is in the same sense that we now use it to signify a gentleman's residence in the country. As a villa is to be a place of agreeable retirement, and not one of seclusion from the world, it should be situated, if possible, in a beautiful country, within reach of a public road, and at an easy distance from the city. Were we to select a residence *of this description*, we would choose a country neither flat nor mountainous, varied with hill and vale, and rather approaching to the mountainous than to the dull monotony of a level surface. We should prefer a situation removed about a mile from a great public road, and not exceeding a day's journey from the city. Here we would enclose a park of one hundred or one hundred and fifty acres, bounded on the north and west sides of it by lofty wooded trees; on another side, by a road; and elsewhere, by the enclosed country of the district; the surface of the park varied, but generally inclining to the south,

with a rapid stream of water passing through it at no great distance from the site of the house. The park, in form, should be irregular—neither round nor square—but the length greater than the breadth. The country itself would, in great measure, determine the line of the boundary fence. Near to the woody hill, on the north side of the park, on a gentle eminence, should be the situation for the house; and we would so place the principal front as to be seen from the public road, and to command a beautiful and extensive prospective over a fertile country—having, in the middle distance, a town or village with its “heaven-directing spire” reflected in the broad reach of a noble river, and, in the extreme distance, a mountainous country, or the sea—the foreground of the view to be well broken up by the timber in the park. The house should stand near the north boundary, nearly but not quite in the centre of the length of the park, which we would divide into three unequal portions. That portion which would be before the house, should be an open lawn of an irregular shape, crossed obliquely by the stream, widened in parts, and having the banks fringed with underwood and a few trees—the lawn itself being broken irregularly with thorns, holly, furze, fern and trees; and varied, where the surface indicated a place for them, with groups and single trees. The other two portions we would make unequal—the smallest towards the village. There should be laid out, in imitation of forest scenery, with open glades and thickets, an irregular lawn in each, with occasional openings to the principal lawn before the house, and to the distant prospect, or any picturesque object in the surrounding country—taking advantage of the inequalities of the surface, and following as closely as possible the most beautiful natural scenery. An irregular green, drive or walk may be formed around the whole. As to trees, we would have every kind of forest tree that soil and space would allow; but we should prefer the oak, sycamore tree (one of the noblest trees when old).

the elm (narrow leaved), Spanish and horse chestnut, the maple, hornbeam, and a few others. Of course we should add lower growths, such as thorn, holly, broom, fern, and even furze. To have a close, even turf, which is one of the chief beauties in park scenery, we should keep it well stocked with cattle, young horses, sheep, and, if possible, a few deer. Many parks, beautiful in themselves, convey an unpleasant feeling of dullness and solitude. Cattle and domestic animals always give a certain air of cheerfulness to a park scene; but still the effect is often solitary, where there is no appearance of human habitation besides the mansion. An ornamental temple or summer house; a pigeon house—often a very picturesque object; the keeper's lodge, which should be within the park; and even a few gables of the farm buildings, seen at a distance—would all contribute to give the effect of cheerfulness and a pleasing variety to a richly-wooded park. We should even wish to have a public foot-path across it and within sight of the house, though at such a distance as to be no inconvenience. Nothing is more cheerless than that exclusive, solitary grandeur, so much affected in the present day, which forbids the poor even to set a foot within the precincts of greatness. As the most beautiful landscape is incomplete without figures, so the general effect of a park is always lonely, unless it have a foot-path frequented by the picturesque figures of persons less favored than the occupant of the villa, and giving life and interest to the scene. Even the line of a foot-path is in itself beautiful, and breaks the monotony of the green turf.

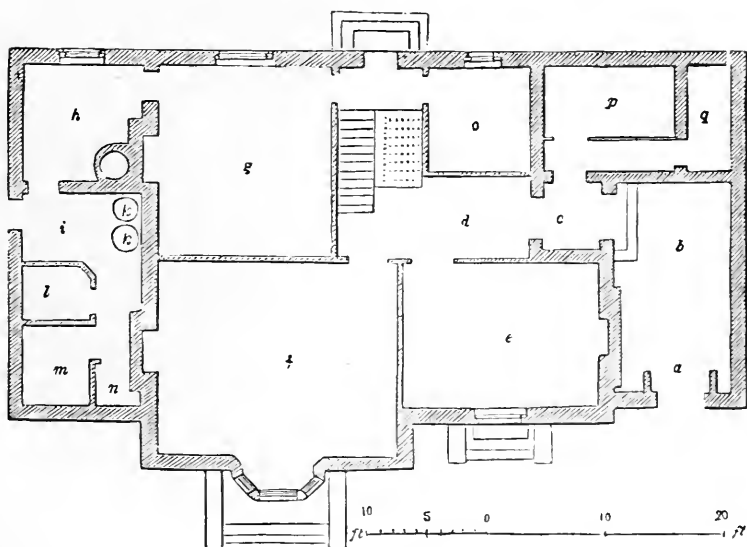
The next appendage to the villa which requires attention is the farm. Every person occupying a residence such as we have described, should occupy a farm of sufficient extent to supply the family with provisions—such as meat, bread, poultry, milk, butter, cheese, &c. The perfection of rural economy is to purchase nothing which the estate can be made to produce; and the advantage of this system,



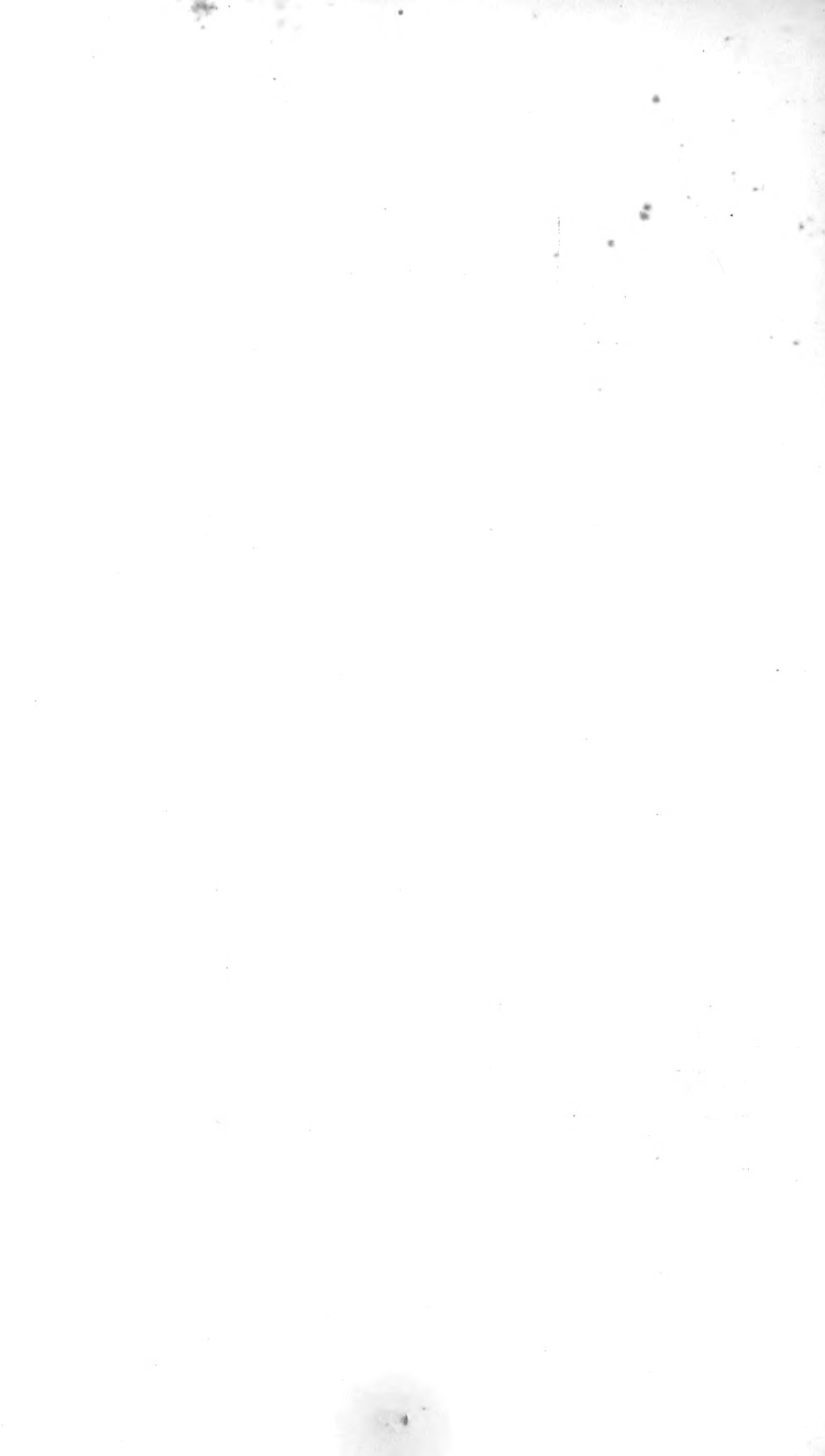


RURAL HOME, No. 1.

[See p. 217]



GROUND PLAN



under judicious management, is, that you have an abundance of everything, and a liberal style of house-keeping, at prime cost. Thus, under the system of management supposed, besides the ordinary provisions supplied by the farm, the estate might afford game and wild fowl. If it be said that it would be, perhaps, better economy to buy than to produce these luxuries, we answer, that in that case, things are not well managed; and probably the owner of the place is a thoughtless, idle person, who does not make himself acquainted with his own concerns. But supposing it to be rather more expensive to produce than to purchase these luxuries; at all events, when you produce them, you have then an abundance; they are always ready on any sudden emergency; and you can have them much oftener.

In "RURAL HOME No. 1," the style of architecture intended to be conveyed by the elevation is decidedly of Swiss origin and the general form perfectly simple—the variety in the external elevation being produced by the projecting roof. The protected bay window also tends to enliven the design, and is always an agreeable addition.

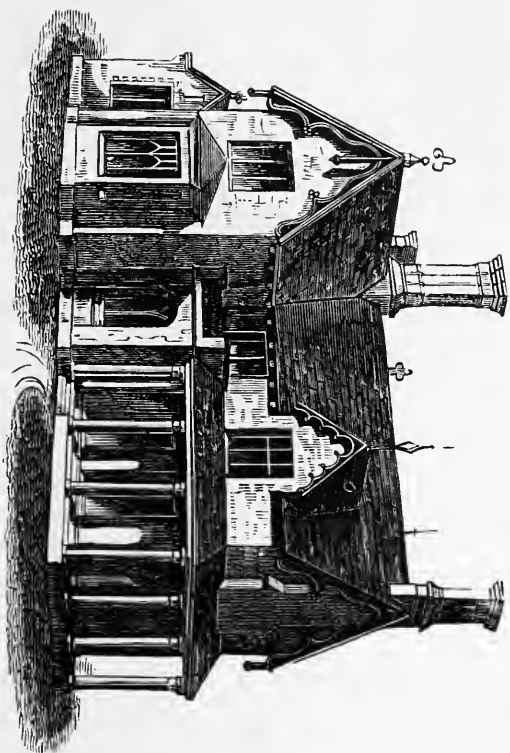
The accommodations are as follows: *a*, entrance to office; *b*, office; *c*, clothes-pantry; *d*, main hall and staircase; *e*, reception-room; *f*, parlor with porch; *g*, kitchen; *h*, cook-room; *i*, scullery; *k, k*, water tank and sink; *l, m, n*, pantries, closets, &c.; *o*, sitting-room; *p, q*, water closets, &c



These embellishments embrace two views of a suburban residence, in the English castellated style, strikingly illustrative of the great beauty attainable by a happy mixture of the different orders.



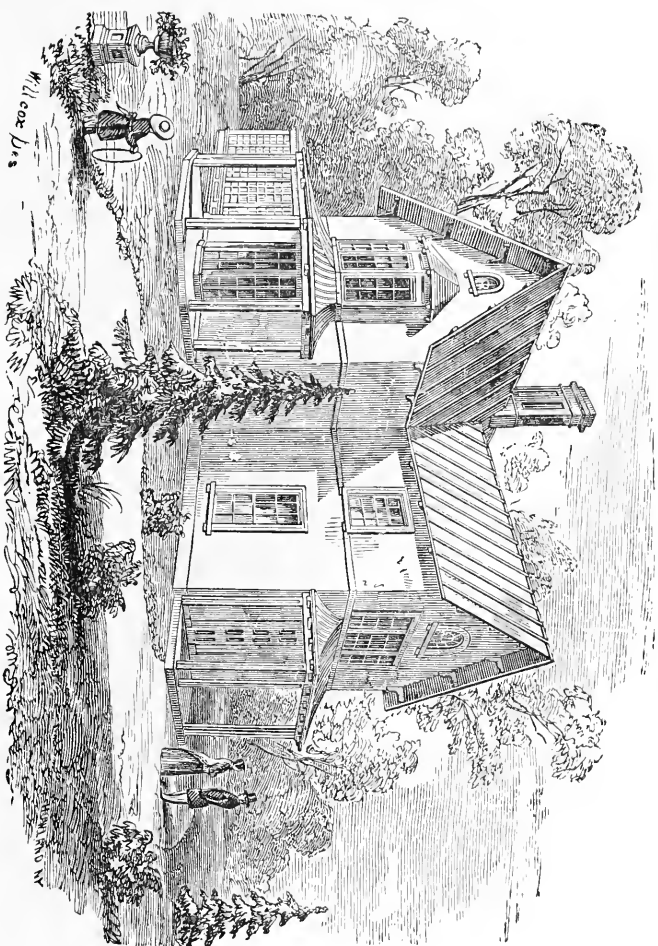
In connection with "RURAL HOME No. 2," we have the following description: "We bethink us of a cottage in the pointed style, a mixture of Elizabethan and Gothic, situated adjacent to the beautiful Hudson. The house approximated to the tasty—but we must term it the mongrel order—and was all that the most fastidious could require; in fact, the acme of convenience, comfort and beauty; but the features that comprised more particularly the *beau ideal* of elegance, was the green, velvety, undulating lawn, which occupied that portion of the estate directly fronting the mansion, spreading over an area of nearly half-a-mile in extent, interspersed with islands of shrubbery, clumps of evergreens, tall, spreading pendulous conifers, umbrageous oaks, rare trees from far distant climes, covered with all the luxurions foliage and flowers of the tropics. Another attribute, and by no means an unimportant one, was the garden contiguous, forming a sort of back ground to the lawn, in which luxuriated the more tangible and substantial requirements of our corporeal existence. There flourished the luscious peach, with its downy cheek, the buttery-melting



RURAL HOME.—No. 2.

[See page 218.]





RURAL HOME—No. 3.

[See p. 219.]





pear, the red-checked cherry, the golden apricot; and, peeping out, nearly smothered by its own habiliments, we discovered that never-cloying delicacy, the strawberry, as if endeavoring to escape that inevitable destiny peculiar to strawberries, of being smothered in cream. These were but a tithe of the many provocatives and inducements to sojourn in the country, by which we were surrounded.

The beautiful cottage "No. 2," is a design by LUDLOW. There are many reasons which would lead a person to select the mixed style for a country residence: for instance, it is more picturesque and ornamental; it best accords with rural scenery; and, as it admits of great irregularity of form, it affords space for the various offices and conveniences necessary to a country home. In the accommodations of the ground plan, we have an entrance porch, which is to be finished with a coned roof, and to have Gothic niches in the angles for statues, &c. From this we pass to the hall and staircase by a Venetian door, the upper part of which is glazed with stained glass; thence to a small ante-room, from which there is a door, to the covered terrace. From the hall we enter the dining-room, containing two windows, which are to be brought down to the floor and to open like French casements, so as to admit of easy access to the terrace when the ante-room is occupied. From the hall, we likewise enter the drawing-room, which has a door to the ante-room—also to the kitchen. The kitchen door from the hall is finished, on the staircase side, in the same manner as the doors of the principal rooms. This door will only occasionally be used as an entrance from the porch to the kitchen, as there is an entrance through the yard and wash-house for servants, etc. The above description embodies all that our plate recognizes.

In the engravings representing "RURAL HOME No. 3," we have a beautiful design by Mr. W. H. WILLCOX, a young Architect of much promise. We give the artist's own words:—

"The design of this cottage is simple yet expressive, and is of the modified Italian style; a style which, with its broad, overhanging, bracketed roofs—sheltering thoroughly the walls from the weather—and pleasing piazzas, is well adapted to our northern climate; and while there is nothing difficult or expensive in the construction of the various details, its bold, projecting roofs and bay windows give character to the exterior. It is intended to meet the requirements and exigencies of a small family; and, simple and inexpensive as it is, it contains more of the *real* essentials which a house should possess, than many that have cost double the sum."

The plan of the principal floor sufficiently explains itself, showing an ample hall, with a handsome staircase (this hall might be used as a sitting-room) abundantly lighted, and giving easy access to both drawing and dining-rooms, and by means of a lower staircase, to kitchen and other basement apartments. There is also a back door opening to rear of house. The drawing-room is fifteen by twenty feet, with a large semi-octagonal bay window, surrounded with a piazza, affording an agreeable accompaniment. At the end, the green-house or conservatory is entered by means of a sliding-sash door; and to add to the effect produced, a fountain of pleasing proportions might, with great taste, be introduced. The dining-room is fifteen by twenty feet, also provided with a bay window, and contains a good closet. The bay windows (the semi-octagonal being carried up in the second floor,) form very striking features in this design, and the result is not altogether unpleasant.

The basement contains a good-sized kitchen, with its several adjuncts of pantry, closets, &c.; a cellar, laundry, and store room, all sufficiently lighted—the kitchen being almost above ground, owing to the surface on this side falling off sufficiently for that purpose.

The second floor contains three bed-rooms, a bath-room, water-closet, and several closets—those indispensable attach-

ments to every country-house. In the attic we have two rooms, large open attic closets and cistern. All the rooms are quite large, adequately ventilated, and showing a very convenient and compact arrangement; one where comfort and good effect are combined to a very considerable degree. No flimsy ornamentation or filigree work enters in the slightest degree into this composition. All is plain, simple and expressive, as a *cottage* should be.

The great criterion of perfection in design, is, that all the parts about a building should be subservient to *convenience*, *construction*, and *propriety*. Discard these, and we have a building at once unsatisfactory. Discordant emotions immediately supplant those of harmony.

Says a celebrated writer: "If you cannot be consistent in decoration, at least be consistent in the omission of it, and do not seem even to *aim* at what you can only imperfectly accomplish. If circumstances prevent you from producing a finished picture, do not work up in parts, here and there, while others are merely sketched in. In a word, attend to *keeping*." And this is good, sound advice. Were it more attended to, we should not be grieved to see such enormous sums irrecoverably sunk to produce that beauty (?) which, although it may seem to please the vulgar taste for a time, does not fail to end in disappointment.

Decorations that are added to the essential portions of cottages, require the same degree of judgment and judicious application as relates to other works of art. They should be distributed with discrimination and economy, and should be conformable with the character of a country residence: and all ornamentation applicable to the interior, should exhibit a rural air, expressive of the liberty, enjoyment and gayety, that reign supreme in the country.

As we too often see them, cottages are made to put on affected airs, and ape palaces and castles. Great care is taken that the exterior shall "show to advantage," and consequently we see filigree work and gew-gaws nailed on

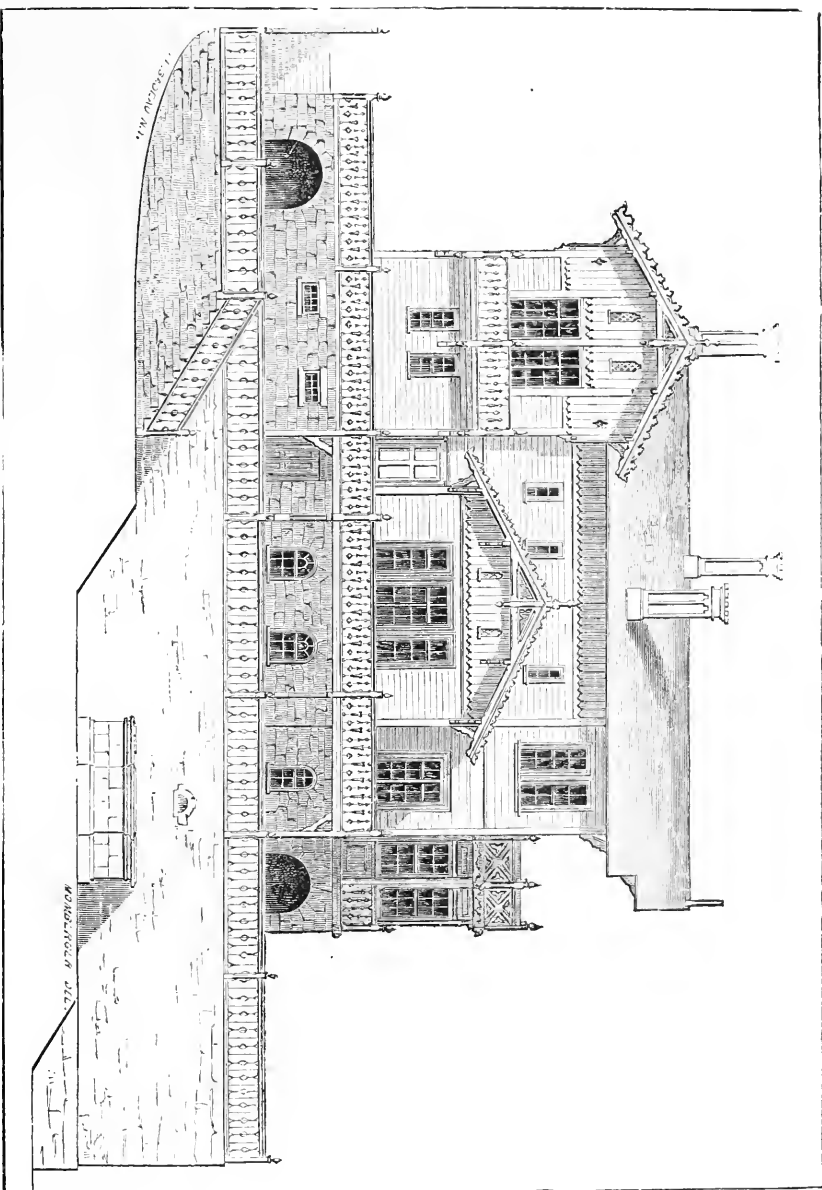
in places where neatness and modesty should appear; and what with pinnacles, turrets, battlements, and other objects, which a nomenclator would find it difficult to assign any particular title, we are induced to exclaim with Petruchio—

“What! up and down, carv’d like an apple tart?  
Here’s snip, and nip, and cut, and slish, and slash,  
Like to a censer in a barber’s shop:  
Why! what, o’devil’s name, tailor, call’st thou this?”

Perhaps nothing is more indicative of the character of its occupants than the external appearance of a country dwelling; a house standing in an exposed situation, costly though it may be, has a very repulsive and uninviting appearance. No grateful shelter of umbrageous trees and shrubs offers to protect us from the scorching rays of a summer sun; and it is but natural to portend the want of taste, as well as intelligence, in those who occupy it. But far different is the result of the neat cottage, surrounded with shady shrubs and trees; and though the cottage be ever so humble in its pretensions, it has a clean, tidy appearance; and, with its grounds richly cultivated, its flowers

“All woven in gorgeous tissues,  
Flaunting gayly in the golden light,”

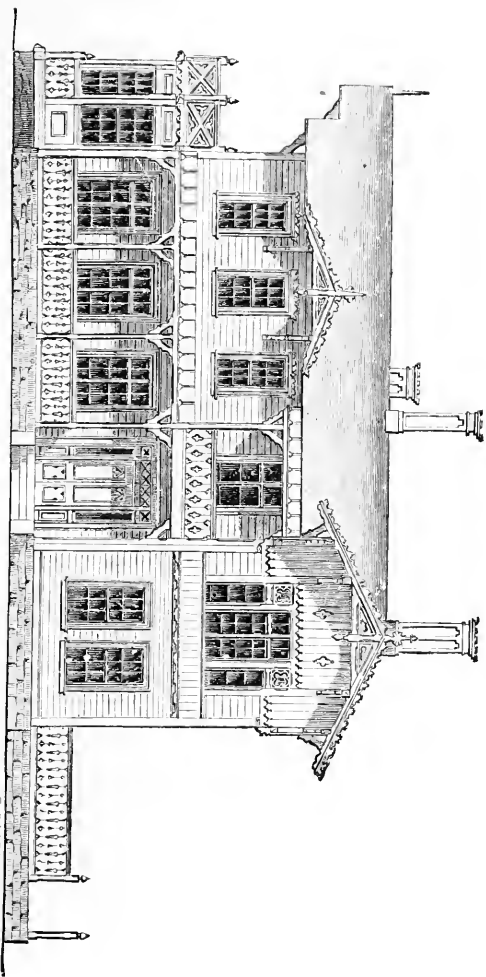
shrubs and trees pleasantly disposed, and a patch of well-kept lawn, are indicative of attention paid to other than “mere animal enjoyments.” Nor is this privilege denied to any possessor of a country residence, for the most limited spot of ground may be adorned with much beauty and effect. It may be laid out with winding or curved paths, neatly bordered with various flowers, blending their gaudy colors harmoniously together; planted with a goodly assortment of shade trees and ornamental shrubs, of which there can be ever had a bountiful variety; a trellis here, with climbing plants; a bower there, with its cool, refreshing shade; a few vases, disposed with care over the lawn, receptacles for flowering plants. These, and more (according as the place is larger or smaller) are susceptible of giving an air of refine-



RURAL HOME, No. 4—NORTH ELEVATION.

[See p. 293.]



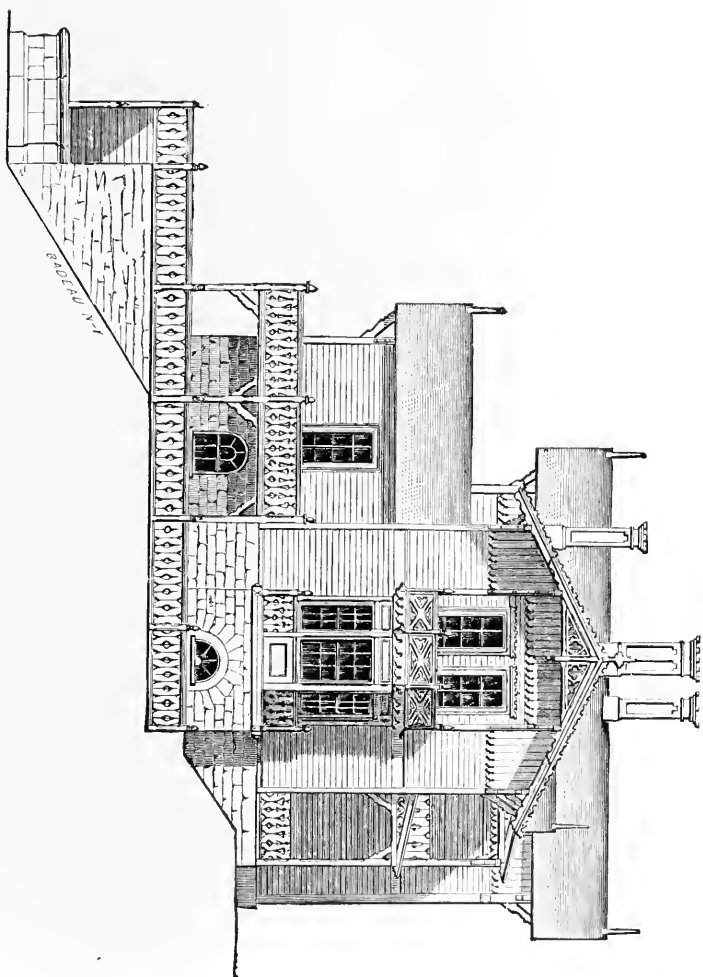


RURAL HOME—No. 4.  
SOUTH ELEVATION—EIGHT FEET TO THE INCH

[See p. 223.]







RURAL HOME. No. 4.—WEST ELEVATION. [See p. 223.]



ment, otherwise quite unattainable, and at a very slight expense. Were our country residences more generally decked with simplicity and taste, we imagine that the number of our young men who wander from the patrimonial estate, and precipitate themselves into the dissipated and vitiated follies of a city life, would be very materially lessened.

A great desideratum for the country is the wire fence (such as manufactured by WICKERSHAM, N. Y.) Inconspicuous, and combining in an eminent degree lightness and cheapness, it offers a very striking contrast to the miserable, rickety, zig-zag, post-and-rail fence often met with in the country. It is more durable, and far more economical than any other species of fence, since by this mode no ground is lost or made unproductive, and it combines "taste and ornament with the utmost permanence and security." We hope to see this style of country fencing in more general use than at present.

WM. H. WILLCOX, ARCHITECT,  
381 Broadway, N. Y.

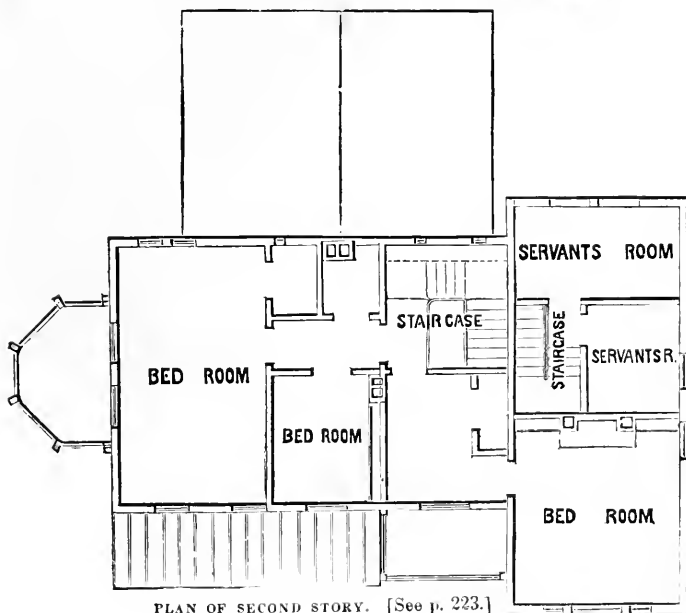
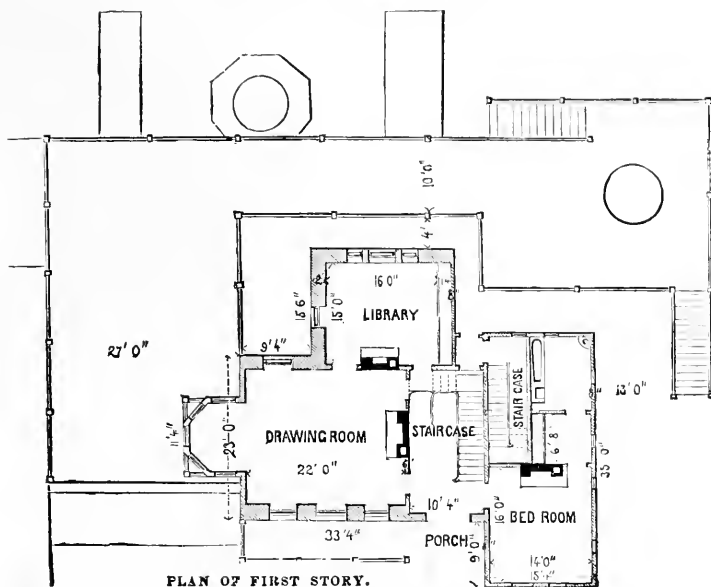
The design "RURAL HOME No. 4," is by Mr. LEOPOLD EIDLITZ, a New York Architect of established reputation. It is in the Swiss style, and is intended to stand on a hill-side, opening on a lawn toward the north. The house possesses great external beauty and harmony and is internally convenient. The view toward the north would, if the house were on an elevation, be quite pleasant; while to travelers on the road toward the south, who see the house as shown in the "South Elevation," (see engraving) the snug, comfortable and pleasant appearance, is quite striking. The "Drawing Room" is in the south-western portion of the house, which, by general consent, is the pleasantest part of the building. All the conveniences of a house of the first class are designed for the cottage—such as baths, water, &c., &c.

Chancellor LIVINGSTON used to prefer a house or country residence situated on ground sloping from the north to the

south. On the most northern portion of the ground he would plant a hedge or grove of trees, to shelter the house from the northern winds or storms. Trees should not be planted close to the house, as they are supposed to harbor dampness, and consequently make the residence unhealthy. It is usual to place trees at least twice as far from the house, as the trees are high; that is, a tree thirty feet high should be at least sixty feet from the house, and a tree forty-five feet high should be at least ninety feet distant from the house. The Chancellor would plant the trees of the largest growth on the extreme north, and come down gradually to the smallest; then from the largest shrubs down to the smallest; then from the largest plants down to the strawberry, which would be on the extreme south. The house should be about two-thirds the distance from the strawberry to the northern boundary.

The pathways, walks, and fences around a cottage should always be curved, rather than straight. HOGARTH found the line of beauty in the letter S—in a curve. This branch of the subject, however, is fully discussed in the chapter on "*Design in Architecture*," in the first book of this series, "*History and Rudiments of Architecture*."

# RURAL HOME—No. 4.





## CHAPTER XVI.

## PAINT AND COLOR.

IN all decisions respecting the relative beauty of objects or of qualities, we find no source of difference and misunderstanding so fertile as the confusion between *ocular* and *mental* pleasure—that which addresses itself to the external sense alone, or through it to the mind alone. Continual mistakes, arising from this confusion, run through everything we see or hear on the subject, from the simple “I like it,” or “I do not like it,” without giving a reason, up to the most subtle and elaborate theories of beauty and taste, as those of Hogarth, Burke, Price, and Alison.

It seems, therefore, that nothing is more difficult than to define the exact boundary between the provinces of the mind and of the eye; or, in an object that pleases both, to distinguish which of its qualities or excellencies address themselves to each exclusively of the other, and which (if any) are calculated to afford pleasure both ways: yet nothing is more necessary than this, in the outset of any rational inquiry into the truth or falsehood of an alleged rule or principle, in architecture or any other fine art.

So great has been the difference of opinion on this point, that some authors (Milizia, for instance) have denied the existence of ocular forms of beauty, *i. e.*, they deny that any form is more pleasing than another to the mere sense of vision, apart from mental inferences or associations; which has led, on the other hand, to the question, whether this sense differs from all others, in having no preference of one sensation to another—no likes or dislikes.

Such an anomalous deviation from the analogy that obtains between all the other senses cannot for a moment be admitted; and accordingly, we shall find that the eye has

its choice and preference of one simple sensation to another, not perhaps with regard to forms, (which cannot be regarded as simple sensations, or even sensations at all,) but certainly with regard to colors, which are the only ocular qualities coming under this denomination. Children and savages, who, in the choice of colors, consult nothing beyond the immediate gratification of the eye, invariably prefer a certain class of colors—those termed crude or positive—to another class—those which we term dull colors or tones. Now, that the preference shown to the former is purely a matter of sensation, with which the mind has nothing to do, will be plain from the fact that the mind has, in these and most other cases, no knowledge whatever of what constitutes the difference between these sensations: it knows nothing of any physical resemblance that may exist between the colors included in each of these classes, which does not apply to the other class; nor have we any name to distinguish these two qualities, otherwise than by their pleasing or displeasing effects. Thus we apply the term *bright* to the more pleasing class; but every one perceives that this is only done by a metaphor, (because light is more pleasing than darkness,) for the pure or positive colors are not necessarily more *luminous* than the others, but only more eye-pleasing. The purer of two colors may be, and often is the darker; and then, in comparing them, we discover the insufficiency of the word *bright* to express what we mean, and are therefore obliged to replace it by the word *rich*—another metaphor, observe, still implying nothing more than fine or pleasing. Thus the preference of one color to another, abstractedly, without reference to fitness or association, must be regarded as merely and wholly a sensuous preference, like that of one simple sound, or one flavor to another. The analogy, therefore, between the eye and the other organs of sense, is complete and unbroken, without any necessity for supposing it to have a preference of one *form* to another.



The discovery, indeed, of a physical reason for those preferences, in the case of two of the senses (sight and hearing)—the discovery why red is more pleasing than brown, or blue than gray, or the sound of a string than that of a stick—that is, the discovery of some describable quality common to the red and blue, and other colors of the same class, and to the string and other musical sounds, which quality is not possessed by the dull colors and the unmusical noises—must be considered one of the greatest triumphs of inductive science. It is now perfectly known in what this difference consists; and, moreover, that it is *the same* in both senses. For, as both light and sound affect their respective organs by an inconceivably rapid repetition of vibrations or pulsations, so, in both cases, it is found that the pleasurable-ness of the sensation, whether of sound or of color, increases just in proportion as these vibrations are more regular, isochronous, or equal-timed; that, in the colors of the spectrum, or the sounds of a glass bell, they are perfectly so; and that the duller or more dead the color or sound becomes, the more irregular are these vibrations, till, when they are totally irregular, we perceive only a sensation, not a pleasurable one, a wooden sound of no definite note, or a neutral tint of no definite color.

An eminent artist has observed respecting *tone*, “a property or quality of color, the opposite of gaudiness or harshness,” that “it bears that relation to colors in general, that the quality of a musical note does to that of an unmusical sound or mere noise. In music this is known to depend upon the vibrations of the air being isochronous, or at equal intervals. Should it be discovered that colors are also produced by vibrations, tone, in its present application, may prove to arise from similar regularity.” But physical optics exactly contradict this ingenious surmise, by disclosing that crude or gaudy colors correspond to musical sounds, and that it is precisely the sober “tones” of color that are non-isochronous, like noises. The error evidently arose

from the artist, absorbed in the higher excellencies of his art, mistaking a mental for an ocular beauty. If he had observed the conduct of children, who look only for the latter, he would have perceived that it is the crude positive colors which are the sweets of the eye, and that the tones are its bitters, or at least, its insipid, ordinary food. In fact, that whenever the latter are preferred to the former in a picture, it is from a mental, not an ocular preference; and a sensuous beauty is sacrificed, as it should be, to an intellectual one.

But for how many ages were these differences perfectly well seen and heard, and these preferences shown—by how many millions is this still done, without a possibility of knowing in what the differences consist? We hence learn that the mind can have no share in appreciating this lowest species of beauty.

So, also, the *harmony* of colors—that is, the preference given to a juxtaposition of two certain colors rather than to that of other two, though equally bright or pleasing when seen separately, must be wholly an ocular beauty; for the mind cannot (by the direct evidence of the unaided sense) discover any relation between red and green, for instance, which does not exist between the blue and green. We can only say that the former harmonize together, and the latter do not. As the mind knows, in general, nothing at all about this harmony, the mind can have nothing to do with an appreciation of it. It required the utmost refinement of modern science to discover that this case is analogous to that of two harmonizing sounds; and even in this latter instance, though most persons would know whether the two notes were in harmony or not, the finest musical ear in the world would never discover, from the sound alone, (unless he has studied acoustics or seen the strings,) that the lengths or tensions of these strings bore certain ratios to each other, and that when the notes were discordant, these ratios were incommensurable. It was very right for the contem

poraries of Aristotle, or Vitruvius, to reason from this to all manner of hidden sympathies between the mind and mathematical ratios—which it perceived without being able to state—which it discovered and yet did not discover. This was the best way of accounting for the fact *then*, the highest generalization that the science of those times rendered possible. It would be a disgrace to science at present, because we have a plain physical reason which not only generalizes all the phenomena of harmony and discord, but brings them under the very same principle that distinguishes between notes and noises. For it is evident that two sets of vibrations which are each regular in itself, and which bear a simple ratio to each other, by uniting together form a vibration which is also regular, and therefore musical; but two vibrations which, however regular, each may be alone, bear no commensurable ratio to each other, will, by their union, produce a totally irregular vibration, *i. e.*, a noise. We may illustrate this principle by supposing two clocks placed side by side, one beating every second, and the other twice in a second; the combination of the two beats will produce a regular repeated sound. Suppose the beating of both be 100 or 1000 times more rapid, and you have the case of two notes sounded together, having the interval of an octave. If one clock beat seconds, and the other thrice in two seconds, or five times in four seconds, a regular sound would also in both cases result; and this would resemble the case of two notes differing from each other by a musical *fifth* in the former case, or a *third* in the latter. But let one clock beat as before 3600 times an hour, and the other 6211 times, as these numbers have no common measure, a whole hour must elapse, before the beat will recur in the same order as at first; so that in listening to this sound, we shall perceive no regularity whatever. This is the case with the vibrations of two discordant notes. They may also be *incommensurable*, so as never to coincide in any length of time. Thus, suppose a grating of bars one

inch apart (including their breadth,) to be laid on one another, of which the bars are three-quarters of an inch apart, or any other distance, exactly expressed in parts of an inch, the two will combine to form a regularly striped pattern, which will be larger or broader, the more complex the ratio between the two gratings may be; the breadth of one alternation of the pattern being the smallest space that contains an exact number of each set of bars. But let the intervals in one of the gratings be an English inch, and in the other a French centimetre; or let one be an inch and the other the *diagonal of a square inch*; as they are incommensurable, no regular alternation can occur, however far the gratings may be extended. This is in general the case with two discordant vibrations.

When the nerve has been affected with a particular vibration, it will necessarily accommodate itself with more ease to a new vibration, the more simple the ratio that this vibration bears to the former; so that those which bear the simplest ratios to each other, are most in harmony with each other. Such is the plain physical harmony, which shows it to be altogether a matter of the ear, and not of the hand.

Harmony in color is perfectly identical with this, only on account of the comparatively limited range of the eye's sensibility to vibration, as compared with the ear. Sir JOHN HERSCHELL considers the whole compass of the scale of visible colors to correspond only to the interval called in music minor-sixth. It happens that in this case there is only one harmonic ratio; that is to say, that, though a given note in music may harmonize with many others, as the third, fifth, octave, twelfth, &c., above it, and one below it, a given color in the spectrum can only have *one* harmonic, viz., that vibration which in music would be called the *third*, either above it (never both, because the scale is not long enough to include them); so that, between the vibrations of two colors that harmonize, there is always the same ratio as between the two *near-*

*est* musical vibrations that harmonize, viz., the ratio of four to five.

As few seem aware of the universal application of this rule to harmony in colors, we insert the following table, in which the first column contains the names of the simple colors; the second column their number of undulations in an inch, according to the measurements of Sir JOHN HERSCHELL. This number being increased or diminished in the ratio of four to five, or five to four, gives that in the third column, corresponding (according to the same authority,) to the color named in the last column, which is, in every case, the harmonic or contrast to that in the first :

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	Undulations per inch.	
Extreme red (crimson),	$37,640 \times 1.25 = 47,050$	Green.
Red, . . . . .	$39,180 \times 1.25 = 48,975$	Bluish-green.
Reddish-orange, . . . . .	$40,720 \times 1.25 = 50,900$	Greenish-blue.
Orange, . . . . .	$41,610 \times 1.25 = 52,012$	Blue.
Orange-yellow, . . . . .	$42,510 \times 1.25 = 53,137$	Indigo blue.
Yellow, . . . . .	$44,000 \times 1.25 = 55,000$	Purplish-indigo.
Yellowish-green, . . . . .	$45,600 \times 1.25 = 57,000$	Violet.
Green, . . . . .	$47,460 \div 1.25 = 37,968$	Crimson.
Greenish-blue, . . . . .	$49,320 \div 1.25 = 39,456$	Red.
Blue, . . . . .	$51,110 \div 1.25 = 40,888$	Orange-red.
Indigo blue, . . . . .	$52,910 \div 1.25 = 42,328$	Yellowish-orange.
Indigo, . . . . .	$54,070 \div 1.25 = 43,256$	Orange-yellow.
Purplish-indigo, . . . . .	$52,240 \div 1.25 = 44,192$	Yellow.
Violet, . . . . .	$57,490 \div 1.25 = 45,992$	Yellowish-green.
Extreme (reddish-violet)	$59,750 \div 1.25 = 47,800$	Green.

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It must be remembered that each color in the first or last column is harmonic, not only to the one placed in a line with it, but to all modifications thereof ; that is,

1. To all its *tints*, from the purest or most intense color up to white.

2. To all its *shades*, from the same pure color down to black.

3. To all its *shaded tints* or *diluted shades*, formed in

painting, by mixing it with both black and white in any proportion; or, in other words, with any *neutral* tint in any proportion.

4. By mixing it with any exact harmonic color in any proportion—for every color neutralizes an equivalent portion of its opposite color, so that painters who wish to avoid blackness often paint the shadows on a colored object, not with neutral tint, but with the color opposite to that of the object; for, by this means, its color may be lowered most with the least diminution of luminosity.

No one could discover the harmony of 4ths and 5ths from the inspection of a red and a green, or any other two harmonic colors; so that this, no less than abstract beauty of single colors, is purely an ocular beauty, arising from the retina of the eye, when impressed with a certain vibration, accommodating itself most easily to a new vibration that bears a simple ratio to a former one. Colors that harmonize are commonly said to form *contrasts*; at least, such is the case if they be both of equal purity and intensity, which, however, is not necessary to harmony. A nice distinction has been attempted to be drawn between *simultaneous* and *successive* contrasts; but the fact is, they are always successive; for when two colors are placed in juxtaposition, the continual motion of the eye-balls bring the image of each, alternately, over the same portion of the retina; and each point of that delicate nerve is successively exposed, in an inconceivably short time, to each and all of the colors that may happen to be before us.

On the whole, it would appear that the laws of coloring, as a gratification of the *eye* only, are simply these :

1. That the more isochronous (or equal-timed) the vibrations of any given color may be, the more pleasing will it be in itself, apart from fitness or association with others.

2. That these isochronous (or equal-timed) colors, however, have a more exciting effect on the retina than those which are of the same brightness but not equal-timed; the

repose afforded by a change from the former to the latter is also grateful; so that we should follow the example of nature's works, throughout which the sober, mixed, or subdued *tones*, are the rule, and the pure or isochronous *colors* the exception; for it is a less evil to be unable to find excitement, than to be unable to find repose.

3. That *variety* of coloring is abstractly, (without reference to fitness, &c.,) more pleasing than monotony—especially when the colors that adjoin each other have their vibrations in the harmonic ratio of four to five; that is, when they form contrasts, and still more when they are varied in intensity or brilliancy, or both, as well as contrasted in quality.

4. That, as variety is an exciting quality, owing to the rapid changes which each point of the retina undergoes, the change from variety to sameness of color is required for repose; so that here, again, we should imitate nature, in which sameness of coloring is the rule, and variety the exception; the former being found in all large and grand objects, and broad surfaces, and the latter only in small and scattered organisms.

This would lead us to infer that in architecture, or at least in its grander forms, varied coloring should have as little place as it has in the elephant, the oak, or the mountain-chain. In this connection we would state our opinion that the new architectural sect of poly-chromists who have placed themselves in opposition to the general opinion of civilized man for the last two centuries are wrong.

A proper understanding of the nature of physical harmony, whether in sound or colors, will guard the reader against the immense abuse which mystics make of this common sense principle, in the theories of what is called *proportion* in architecture—a sort of beauty-made-easy, an artistic philosopher's stoupe, by which baser productions are to be transmuted into works of art; expressions of thought, without the trouble of thinking, only by applying arithmetical

rules. It will be seen that, while the analogy between sounds and colors is real as far as it goes, there is no sort of foundation for the extension of these ratios to the *dimensions* of visible objects, except the active imaginations of ancient ill-informed philosophers, who in these speculations did their best, while their modern followers do their worst. Why should the height and breadth of a window bear a certain simple ratio to each other? Because, says VITRUVIUS, two strings of the same thickness and tension, having their lengths in the same ratio, will yield concordant notes. The logic is truly admirable; but it was a very fair deduction for the science of that day, and only unfit for the present, because we happen to know *why* the notes harmonize, and it is for a reason which has nothing at all analogous to it in the case of the window. If there be any architectural analogy, it is in the case of equally-spaced rows of objects, placed one tier over another, as the ornamental mouldings of a cornice, which in many ancient buildings are *not* (as is now the universal practice) regulated so as to harmonize, *i. e.*, so as to have an exact whole number of dentals in another moulding, or of eggs and anchors in another.

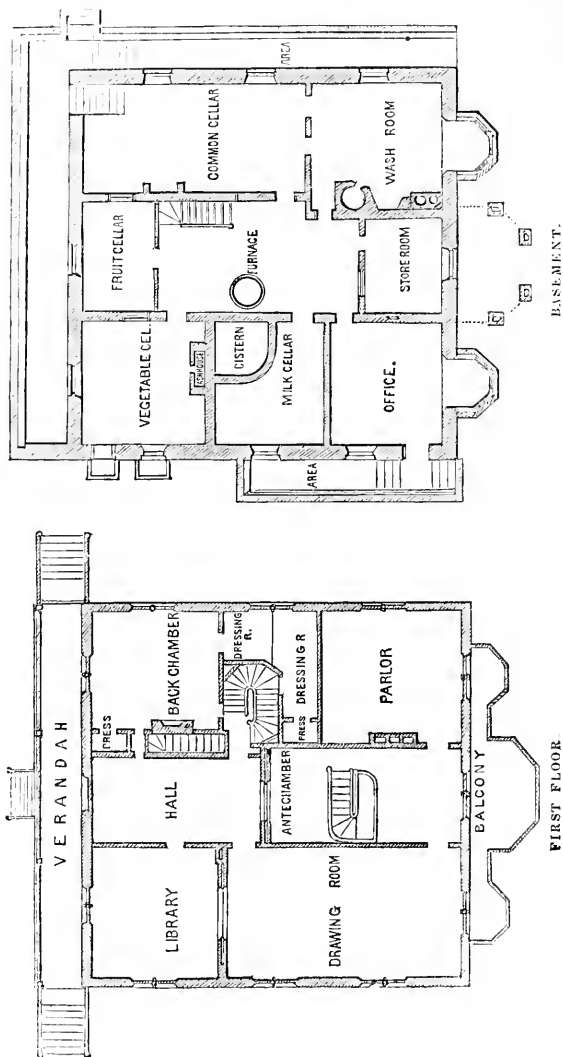
It is not within our present purpose to give a review of the painter's art: that subject cannot be properly treated alone in a work of less dimensions than this.

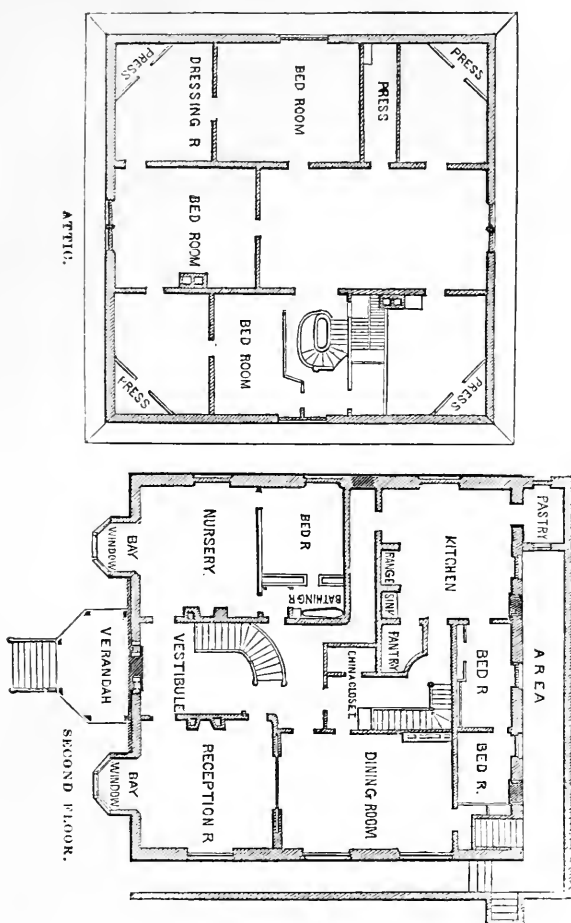


## CHAPTER XVII.

## SUBURBAN RESIDENCES.

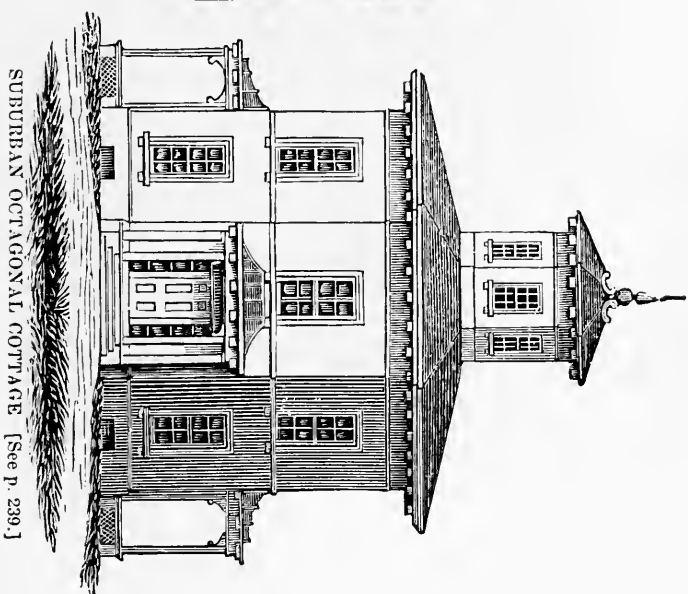
THE GOTHIC SUBURBAN COTTAGE (*see Frontispiece*) is the residence of C. PRESCOTT, Esq., Troy, New York. The original plans were designed by his intelligent lady, Mrs. PRESCOTT, who, not being an Architect, called to her aid H. THAYER, the Architect by whose united labors the designs and plans were completed. The material of which the house is built is brick. The foundation is stone—two feet thick. The first story walls are sixteen inches thick; the other walls are one foot thick. The inner walls stand four inches from the brick, and are *hard* finished. The outer walls may be either painted in imitation of stone, or plastered with *stucco* or *concrete*. The building is warmed by a furnace, or heater, being placed in the basement. The water which collects on the roof is taken to a cistern in a cellar, and close to the house is a spring of clear, pure water. The situation of this house makes it singularly beautiful, and desirable; it stands on a hill, in the eastern part of the city of Troy, N. Y., and faces, from the west, the Hudson River, and takes in a fine view of it for several miles, north and south. At the south is the city of Albany and a beautiful Rural Cemetery; immediately in front is the city of Troy, West Troy and the United States Arsenal; to the northerly is Mount Olympus, the Troy Cemetery, Lansingburgh, the State Dam, Cohoes, and Waterford. In connection with these are the canals and railroads, with their ever-busy vehicles. The owner of the house has a large stream of water, some four hundred feet east of the house, from which he intends to bring the water in pipes to his residence





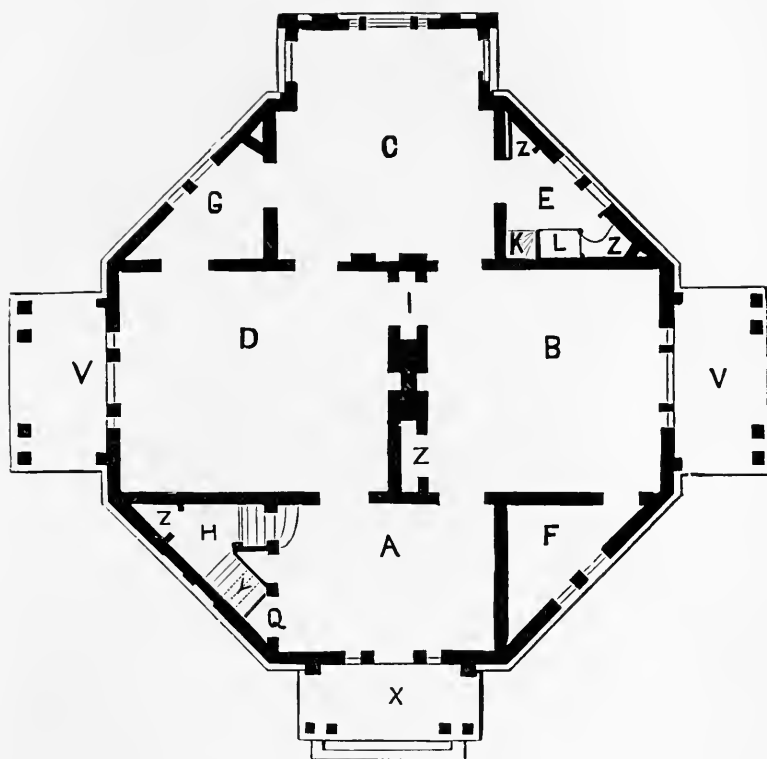
The head of the water being forty feet higher than the foundation of the house, all the rooms will be supplied as well as the fountains, which are to be placed in the front and on the sides of the house. Between the building and the head of the water-course there is a large ravine, 180 feet long, 100 feet wide, and 70 feet deep, of which the owner intends to make a fish-pond—it now being well known that fish are as easy of cultivation by artificial means as strawberries, and that they can be made perfectly tame, being quickly called by the human voice or the sound of a bell. The day is not far distant when a fish-pond, filled in abundance with the rarest fish, will be as frequent an adjunct to a Villa or Suburban Residence as sheep on the lawn, a bird in the cage, or a rabbit in the yard. The ravine is surrounded with trees, and wild vines run riot up and down and over the rocks, making it a most delightful place. Its proximity to the city renders the use of gas an easy matter.

It will be observed that this house possesses one of the most captivating requisites of a suburban residence. It has at one and the same moment a wide and extended view of the country, rural and commercial; the river and the railroad; the canal and the waterfall over the dam; the mountain and the rustic cemeteries; men in busy life, and the tombs of the silent dead; churches with their spires peeping over the distant green hills, an emblem of man's better nature struggling upward from earth, even though she be decked with beauteous, but enticing flowers. Within and about the house, all is rural beauty, quiet, comfort, and peace. On a Sabbath morning, no matter whether the wind comes blowing from the north or the south, from the east or the west, it bears the welcome sound of the church-going bell, inviting men to repose. The rippling of the stream in the brook is a silver tone, which, to him whose mind is tuned to harmonious beauty, is in harmony with the bells. Nature answers unto art and art unto nature. The silver streamlet ever singeth the song of rest, till now and



SUBURBAN OCTAGONAL COTTAGE [See p. 239.]



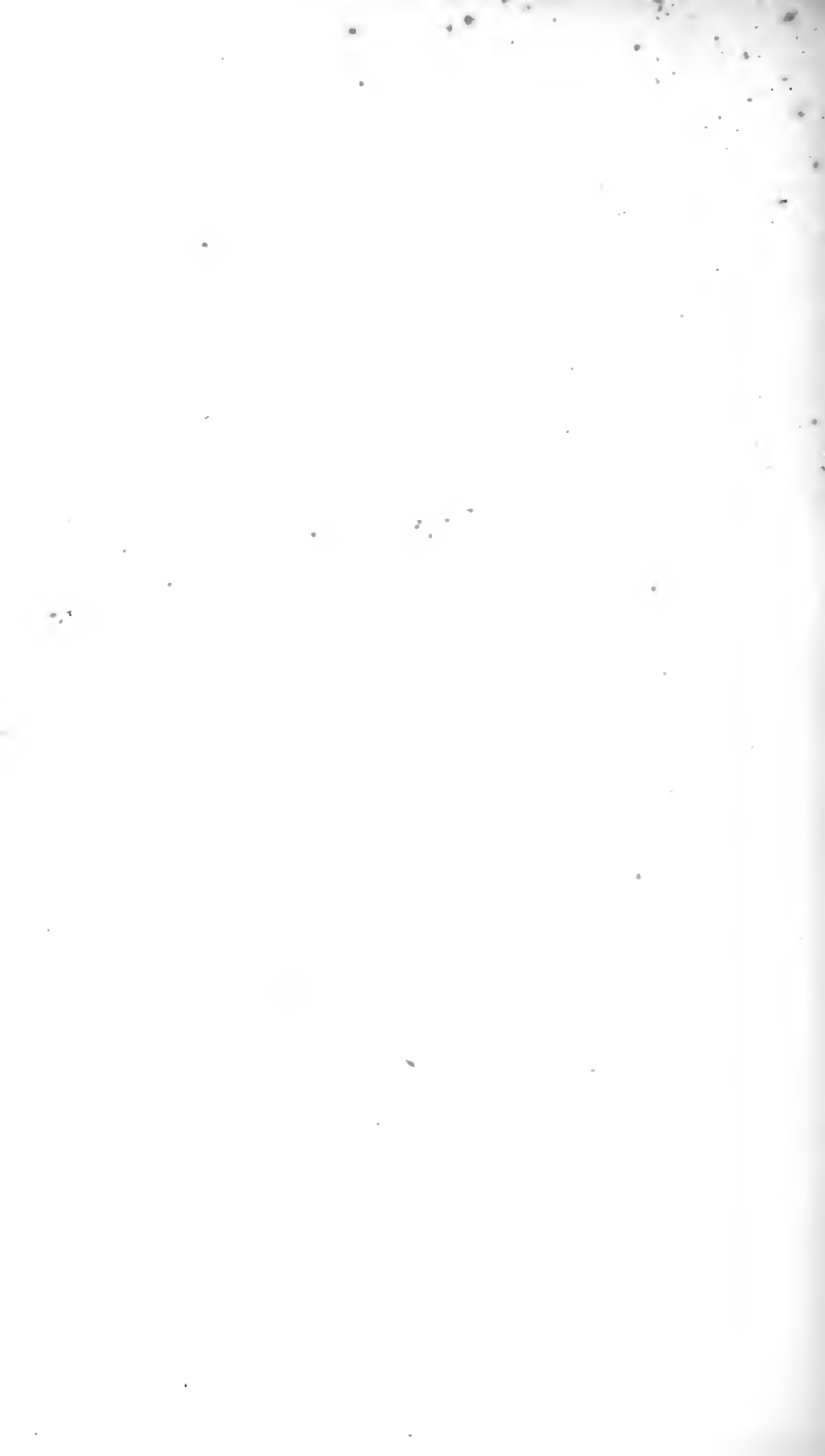


PRINCIPAL FLOOR OF OCTAGONAL COTTAGE.

[See p. 239.]

# REFERENCES.

- |                       |                                |
|-----------------------|--------------------------------|
| A. Entrance Hall.     | O. Bed Rooms.                  |
| B. Sitting Room.      | P. Servant's Bed.              |
| C. Dining Room.       | Q. Hat and Coal Closet.        |
| D. Drawing Room.      | R. Bath Room and Water Closet. |
| E. Waiting Room.      | S. Stairs to Attic.            |
| F. Boudoir.           | T. Cleaning Room.              |
| G. Green-house.       | V. Verandas.                   |
| H. Principal Stairs.  | W. Slops.                      |
| I. Lobby.             | X. Entrance Porch.             |
| K. Stairs to Kitchen. | Y. Closets under Stairs.       |
| L. Table.             | Z. Closets.                    |
| M. Upper Hall.        | 2. Dumb Waiter.                |
| N. Passage.           |                                |





then the distant bells doth answer. The cost of the house was \$15,000.

THE SUBURBAN OCTAGONAL COTTAGE is a design by WILLIAM H. WILLCOX, Architect. We give a description in his own words:

"The above elevation and accompanying plans, represent an octagonal cottage suitable for a suburban residence, and calculated to come within the means of the majority of our citizens. It can be built well (if of wood) for about \$1,500.

The number is comparatively small, of those who are aware of the great economy of the octagonal over that of the square house, and the decided advantages to be derived therefrom. For suburban residences this octagonal form is peculiarly well suited.

An octangular house encloses *one fifth* more superficial area (with a given extent of external wall) than the square. It offers less resistance to the wind, looks equally well from all points of view, and, what is infinitely of greater account to housekeepers, furnishes an abundant supply of closets; and, were it not for the superior *rural* effect of the irregular cottage, (for those of course who can afford to gratify their will,) we have not the slightest doubt that this octagonal form of building would be in universal repute. But to our arrangement :

The first or principal floor contains a good entrance hall; on the left-hand side, as we enter, is the principal staircase, separated from the hall by an arcade of three arches, which impart a cheerful, pleasant effect. The staircase is open to the attic floor, and is lighted from a second story window, (the glass of which for effect might be slightly tinted.) The door to the right, opposite the entrance door, opens into the sitting-room, the one to the left communicating with the drawing-room. In the sitting-room a good closet is on one side of the fireplace, and a door corresponding, on the opposite, leads to the drawing-room, or parlor; on the

hall side of the sitting-room is the boudoir, and on the opposite side is the dining-room door, which we will now enter. This room acquires its size principally from the extension carried out from the building a few feet, and made so as to correspond exactly with other portions of the room, both as relates to construction and finish, and lighted from a triple window at the end; on one side is the serving or waiting-room, in which is placed a triangular dumb-waiter, leading from the kitchen below, a private stairs also communicating with the kitchen and pantry. On the other side of the dining-room is the green-house; and small though it be, it might answer all the purposes required by a small family. To add to the effect, a small fountain might be added at a trivial expense. The doors leading to the green-house and waiting-room are sash doors. On leaving the dining-room by the only remaining door, we enter the drawing-room, between which and the sitting-room a lobby intervenes. There is also a door opening to the green-house from this room. The drawing and sitting-rooms are each lighted at the ends with a bay window. All the rooms on this floor are ten feet high.

Descending to the basement, we will now take a hasty glance at the disposition of that floor, before ascending to the second or bed-room floor. Going down by the way of the principal staircase, we find a kitchen under the sitting-room, with a pantry, scullery, laundry, fuel-room, store-room, milk-room, several closets, and a cellar, all conveniently arranged, and with a view to the saving of steps as well as time. We will now turn back and ascend to the second floor. We arrive upon a landing at the head of the main stairs. This landing, or upper hall, is six feet nine inches wide. The first door on the left leads to a bed-room, as also the first on the right. The second door on the right opens to the principal bed-room, and on one side is a bath-room and water-closet—appendages necessary to every house of any degree of pretension; and on the corresponding side we are furnished with

a large linen-closet. This room might also be used as an upper parlor or sitting-room, if the necessities of the owner required it. Stepping again into the hall, we pass under an arch and are now on our way to the servants' side of the house, the first room entered being the servants' room; and on the side is the cleaning-room, to obviate unnecessary steps and to preserve the seclusive and private character of the principal staircase and hall. In this room are placed closets, a slop inclosure, (by which all slops are conveyed by pipes to a sewer under the basement,) and other necessary conveniences.

Retracing our steps to about midway between this room and the principal staircase, we ascend to the attic, where we may find (if the arrangement of rooms is not sufficient below) other rooms; or, if otherwise desired, a large open space. A cistern is also built under the roof with filtering apparatus—for a plentiful supply of water is most desirable; a staircase leads from this attic-floor to the observatory above, which is thirteen feet in diameter. In this house closets are abundant, and there is an advantage gained in their being of a triangular form.

A word or two upon the placing of a country house and its appurtenances. As regards the situation of a dwelling in the country, it is far better placed some distance from the thoroughfare, in a somewhat retired position, gleaming through a veil of soft, green foliage, than by exposing it to open gaze; the satisfaction thus engendered is of the highest order. Nothing can be more agreeable and pleasing than a long approach; but we would suggest that, rather than not keep it in perfect order, it be reduce in length to within the pecuniary means of the owner; for few persons, without the experience, are aware of the continual drain this long approach compels one to submit to.

In laying out our places of rural retirement, we should do well to imitate the people of England. *They* do not let the house outshine the grounds, but make it somewhat sub-

servient to them; hence the acknowledgment, by almost all, of English taste. Where nature was barren or rude, the hand of English taste has spread a thousand waving beauties o'er the scene—the rill that flows beneath dark rocks and in the melancholy shade of the forest, turns from its course, winds through verdant meadows, swells into the artificial lake, or slumbers upon the plain! “In England,” says our IRVING, “the bleak and arid site is transformed into beauty, and no matter how humble its pretensions, it is made a little Eden. The cherishing and training of some trees, the cautious pruning of others; the nice distribution of flowers and plants of tender and graceful foliage; the introduction of a green slope of velvet turf; the partial opening to a peep of blue distance, or silver gleam of water—all these are managed with a delicate tact, a pervading yet quiet assiduity, like the magic touchings with which a painter finishes up a favorite picture.” Thus are the country residences of England so beautifully described, so openly praised.

Every man of landed property, of what size soever, should be a planter. “Even an old bachelor,” as Professor WILSON says, “is not only free, but in duty bound to plant a tree;” and if his organ of philoprogenitiveness is at all developed, he must feel the paternal solicitude aroused within him, and submit to the instinctive yearnings of his heart.

Many people are prevented from planting trees on account of their supposed slow growth, but this is surely a mistake. As well might people, with the same logical reasoning, be prevented from being married because a male requires twenty-one years to roll past before he attains his majority. It is true that it requires a long time for a tree to arrive at maturity, and it is equally true that trees of a sufficient size (for present convenience, say from twenty to thirty feet high) may be removed. Sir H. STUART planted a tract of land consisting of about one hundred and twenty acres,

and containing trees, some of them as much as sixty feet high, with *perfect success*—and, prithee, why may it not be done here? One need not, then, languish for some finely-formed tree growing in the corner of the “farm,” whose owner grudges it ground room, neither is he obliged to wait ten or fifteen years for the shade thereof.

But ought the supposed slow growth of trees to prevent our planting them? We see no valid reason that it should; besides, who does not feel great joy from seeing the quondam sapling, after a long series of waterings and careful protection, now overshadowing us and returning in a grateful manner the care bestowed upon its progress up, by offering us shade; they, in return, will not suffer the “noonday sun to smite their father’s head.” Who, we would ask, does not realise the fond attachments arising from such paternal anxiety?

If we examine carefully and observe, we shall perceive that the growth of trees is not so dilatory after all; if any one is predisposed to a doubt, let him keep out of sight of them for a short time, and returning under cover of night, hasten on a fine summer morning and take a peep at them! He will hardly recognise the form of a single tree; the arborets that he planted are now trees of shade; the gradual tumefaction has burst asunder the little rods put round them for protection. Then do we recall to mind the “credulous affection” with which “we beheld their tender buds expand.” “Besides, in every stage, how interesting both a wood and sap tree and a flesh and blood child.” Do you perceive yon beautiful rosy-cheeked, golden-haired Gertrude, beholding, with all the cerulean brilliancy of her eyes, the exquisite transparency of that dew-drop “which the sun has let escape unmelted, even on the meridian hours” on yon camelia-bud? What tender emotions fill the upheavings of that tender breast, as this small jewel of nature occupied her attention! That is innocence!

It is true that many of our cottage residences are greatly

improved, and present very striking, picturesque park-like paradises, thanks to the much lamented DOWNING; but there is yet room for improvement; much remains to be done, both as relates to our domicils and our plantations.

WILLIAM H WILLCOX, ARCHITECT,  
381 *Broadway, N. Y.*"

## CHAPTER XVIII.

## LANDSCAPE GARDENING.

A GARDEN is indispensably connected with a rural home. It has been observed, by some writers, that landscape gardening cannot be reduced to rule; that it must be governed by the taste of the architect, and cannot be taught. We will concede the point that no set of rules can apply equally to all places, and that the features of the ground, the nature of the views, the extent of the arena, the presence or absence of water, trees, hills, dales, rocks, swamps, and other features, must dictate to a landscape gardener a good deal of his work; but there are certain rules which can hardly be departed from under any circumstances, and a good deal of useful instruction may be imparted in writing. Nature is our great teacher in this branch of the profession. When we see a beautiful landscape, and are smitten with the harmony of the picture, we may safely study it as a lesson. Is there a straight road? No. Is there any thing formal? No. Is there a square pond, or lake, or river? No. If there be one of these, the eye is offended. If it be not the artificial work of men's hands, it may be wonderful, but certainly not pleasing; the charm would be broken. We find, in all pleasing landscapes, a total absence of all formality; and the gardeuer's task is to imitate the beanties, and to bring into his work as many of the best features as the nature of the ground he has to work on will admit. If the ground be undulating or flat, there must be no sharp turns. A road must be laid down in graceful sweeps; hard lines are always unpleasant to the eye, and must be avoided. Abrupt turnings and elbows are equally objectionable. The same rule applies to rivers or rivulets which run through

grounds; anything like a straight margin is offensive; angles are bad, and whenever such occur, and cannot be altered, they must be concealed. Roads, too, should be, as far as it can be contrived, level, and in undulating ground; the rising, unless very gentle, must be lowered, and each side eased off to a gentle slope on the parts next the cutting. All these things are to be attended to as so many rules, and all deviations must be exceptions forced on the gardener; and his study must then be how they can best be hidden by planting, or reconciled by other schemes. It is rarely that the landscape-gardener has to deal with barren ground; there is usually a quantity of trees of various heights and kinds. It must be his study to appropriate these to his design, or, at least, some of them. If, however, there be any formality or stiffness in their situations—which is frequently the case if he has to take in fields that have been hedged and timbered—a sufficient number must be taken down to break the line, and, on grubbing of hedges, all the common stuff must be destroyed first, leaving any portions that have grown up at all ornamental until a later period of his work; then he may, if he feels inclined, work to them; for it must not be forgotten, that it takes many years to equal things that have grown up well. Not that he is to sacrifice his plan to such an object, but that he must not hastily destroy what may be found highly useful. If a man has an unconditional instruction to form a garden upon his own plan, and to pay no regard to anything that is standing, he will be less inclined to sacrifice any rule, whatever may be there; but there is, nevertheless, as much art in adapting a plan to circumstances, as in carrying out a perfect design, and, perhaps, more; but, as a matter of cost, some hundreds of dollars may often be saved without sacrificing any general principle; and it is the reckless inattention to this, in too many artists, that deters persons from undertaking extensive works. All landscape gardening should be conducted with some regard to economy; and we



mention this because two men may produce results equally good, one having done it at half the cost of the other. LOUDEN, who advocates a mixture of principles, says :— “There appears to be two principles which enter into the combination of gardening; those which regard it as a mixed art, or an art of design, and which we called the principles of relative beauty, and those which regard it as an imitative art and are called the principles of natural or universal beauty. The ancient or geometric gardening is guided wholly by the former principles; landscape gardening, as an initiative art, wholly by the latter ;” but he says, “as the art of forming a country residence, its arrangements are guided or influenced by both principles.” We will not deny that in most estates there will be ample opportunities of indulging both tastes; but the one should be so entirely independent of the other, as not to be even seen at the same time; for the one is perfectly inconsistent with the other, and we consider they may be treated as two distinct subjects. The architect may scratch on paper all he wants of geometric gardening; he will do it to suit his building and his taste; and having done this, the gardener may work to line and rule, and follow his instructions; but let us not compare the one with the other, or mention them as belonging to each other, or having any relation to one another.

POPE says, “The principles of landscape gardening consist of, first, the study and display of natural beauties; second, the concealment of defects; third, never to lose sight of common sense.”

WHEATLEY says, “The business of a gardener is to discover and show all the advantages of the place upon which he is employed, to supply deficiencies, to correct its faults, and improve its beauties.” Another takes truth and nature for his guide, and all his rules are comprised in “the unity of the whole and the connection of the parts.” And MARSHALL wraps all his up in three words—“Nature, Utility and Taste.” We confess our notions of landscape

gardening to be imitating the beauties of nature, and bringing as many of them together as is consistent with the means employed and the site we are at work upon; but we do not, by imitation, mean the mimicry. We have no notion of little waterfalls and puny rocks; no doll's-house arbor's and diminutive lakes; for, above all things, we should lay it down as a rule, that nothing more should be attempted than can be carried out upon a scale sufficiently large to avoid any appearance of art. Nothing can be more contemptible than doing things on a small scale for the sake of crowding more features in a landscape. We do not mean to say that we are to have no rock smaller than Gibraltar, and no lake less than Superior; that our temples are to be as gigantic as the Coliseum, or our rivers like the Mississippi; but that they are not to be less than those scenes which excite our admiration within reach of our ordinary sight; and if there be only room for a plain landscape, it is folly to attempt more. We have seen on one acre of ground three or four tumperry fountains; one broad path with a sweep quite landscape fashion; some very tumperry rock-work, as if somebody had accidentally upset a cart-load of stones; a pond which would have been crowded by a dozen or two of ducks; a mound about as large as a good-sized manure heap, and on the top a temple, so called, which appeared as if the children had left some of their playthings there; we had a shallow canal for the purpose of putting over it a rustic bridge, and at a remote corner—that is as remote as it could be in a place of eighty yards long—a summer house ten feet by six. But certainly the mansion and its appurtenances were of a piece with the lilliputian garden, which, by the way, we had nearly said comprised all the styles: the geometric, the Italian, the old English, and the landscape—and all in sight at once, reminding us of a tailor's pattern card, or the shutters of a color warehouse. The mansion was but one story high, and it had a conservatory, an observatory, a picture gallery, a coach house, sta-

bles, servant's apartments over the latter, even with the hay loft which held four trusses. Then there was a farm-yard with its little barn, cow-house, hen-roost, hay-rack—this was the produce of the farm, and might have filled a one-horse cart—a dairy, quite fanciful, with colored glass windows, to match the conservatory; a kitchen garden, which would have been twenty yards by twenty feet, but a melon ground was cut off it at the end nearest the stable. Some of the boundary was hedged, some walled, some oak palings, and a small portion rustic fence.

Now all this may be thought beside the mark, but it is a general, if not universal failing among owners, to cram in **all** sorts of objects; and as no landscape gardener, who has a name to damage, will undertake such work, the merest pretenders are employed, and the place spoiled by attempting and failing in all that is attempted. Within three miles of this incongruous mass of things, we have mentioned, there was a house with just three-quarters of an acre of land, of an angular form; a twelve feet road pretty nearly skirted it, except to allow of a plantation of shrubs and trees, in which there were openings that led, no one knew where, from appearances, though in fact they were to conceal the real boundaries, and led nowhere; there were a few judicious clumps to account for the necessary turns in the road, and at the most remote angle from the house there was a temple composed of a façade and four Ionic pillars on a floor raised by three or four steps, and forming an apartment fifteen feet square with an open front. However, all but the front was concealed by trees, and although the eye commanded the whole real space, everything was upon such a scale, that it appeared like a very beautiful part of a large domain instead of a three-cornered bit of ground under an acre. We mention these two circumstances to record our dislike for one and our admiration for the other; and we maintain, notwithstanding all that may be said about mixed styles, that the landscape garden should be entirely free from any

thing artificial; and, as we approach a mansion or conservatory, or other architectural object where straight lines are forced on us, let the planting conceal it until we are close to it. Let us step out of natural scenery to the artificial, but not be able to view both at once. Nobody can admire artificial gardening, or rather formal gardening, more than we do, in its place; but what can be worse than the mixture now so common in public establishments—a long, straight road, patched on each side with flower-beds, and a miserable attempt at a landscape within sight? We insist that one or the other should be adopted in earnest. Let the eye fall on nothing but landscape through all the main space, and let the parterres, the conservatories, statues, fountains, geometrical flower-beds, vases, orange trees, and general display, be shut off, so as to form no part of the general scenery. But, according to our definition, the adoption of one style for the flower-garden, and another for the general features, does not warrant the application of the term mixed style. There is no mixture in it. The landscape is to itself; the parterre is alone. In one we have none but geometrical figures; in the other we have not a straight line. For even if the boundary be straight, the planting should alone conceal it. We have no notion, like Alison, that the landscape gardener is “to create a scenery more pure, more harmonious, and more expressive, than any that is to be found in nature herself,” for it is impossible. There are rough and even uncouth scenes in nature; she has her rugged places, her barren mountains, moss-covered crags, and ugly, cold and cheerless spots; but she has features which are inimitable, and he who can even approach them in beauty, and harmony and expression, must be master of his art. Let the landscape gardener do his best to copy some of the most lovely spots on earth, and he will find himself at a very humble distance from his task mistress. But he has one advantage on his side, he may bring together features which are rarely combined, and therefore produce an imitation, how-

ever it may fall short of scenes which few have witnessed. The bend of a river which is grand in one place, and the style of wood which is beautiful in another, a bridge which is picturesque in a third, a summer house that is unexceptionable in a fourth, rocky broken ground that gives great effect may be copied from a fifth, and then comes the gardener's art into play. He has so to contrive his scene, that the whole shall harmonize; and although at every step we take, new beauties still break in upon our view, they shall all be in good keeping. We will now treat of the work under the several heads of ground-work, parks, roads, trees, mounds, valleys, rock-work, lakes, rivers, water-falls, &c.

#### THE FIRST STEPS IN FORMING A LANDSCAPE GARDEN.

We must first contrive to get a complete view of the ground we are to appropriate, and the adjoining lands, and see to the boundary. This of course will be different in different parts of the country. The sufficiency of the ground must first be attended to. If there be a large space of ground, so that we need be under no difficulty as to scope for our operations, we need not trouble ourselves much about timber on the boundary line; but it must be made perfect, whether it be marked by banks and ditches, hedges or palings.

Our next operation is clearing the ground. Here we may have to grub up hedges, so as to break all the interval lines. Rows of timber must be so broken as to remove everything like stiffness. There must not a single line cross the eye. Throw all the worst trees. Save in groups or single trees all that are ornamental, and that may perchance be worked into the scene. If hedges have been neglected, there may be good clumps of thorn and other wood usually found in hedges, and grown up to a considerable height, and what the gardeners call "well furnished," that is, branches reaching the ground, clumps of trees formed as it were by neglect, but nevertheless rich in themselves. They can at

any time be grubbed up, but in the meantime let them remain, wherever they are sufficiently handsome. Let this clearance go on all over the site intended to be brought into the landscape. We may then consider where the entrances are to be, from one or more roads; and we have also to consider what foot-paths or roads there may be of a public nature that may not be shut up; and while there may be parts left open to the view, large parts must be shut out by mounds, planting or other contrivances, and the whole secured to its own track only by sunk fencing, where the view is required to cross it.

Our next consideration is, whether we can, with advantage to the estate and without detriment to the public, turn the course of such paths or roads, for they are often nuisances, and should be removed from the mansion. To obtain a good view of the whole, we must contrive to see it from the highest places, and with such helps as are at hand. The top windows, or roof of the house, or a high tree, or if necessary a temporary scaffolding, must be placed in the best situation. Our general plan must then be formed, although it need not be reduced to paper. If the ground be much diversified with hill and dale, the levels must be taken. Undulating ground is very picturesque, but the roads must be cut level, and the sides, where the cuttings go through, must be formed with sloping banks; but if the ground be a regular slope, or up a long hill and down again, you must consider first, whether the expense of so long a cutting would be advisable, and second, whether it will form or derange your picture. Sloping banks for part of the length of a road are very effective; but the banks must be judiciously planted here and there, and they must be neatly contrived to make them picturesque. According as you mean to destroy or use the uneven surface, so must your preparations be made. If the ground is to be levelled, all this must be done before you mark out your roads.

In short, before you lay down one foot of your plan, all

that must be removed should be cleared away, before you begin anything else.

If, in looking over your work, there happened to be enough cleared to begin, you must endeavor so to shape your course as to appropriate as much of the really ornamental timber and bushes as possible, but you must not be tempted to sacrifice any principles to save a tree. In forming a main road, it is always desirable to bring it moderately near the outside of the premises; and if there be much ornamental wood, the road may be so formed as to command the best view of it. No matter how many windings there are in a road, if the sweeps are very graceful and not in any place abrupt, for convenience must not be sacrificed under any circumstances. The presence of a river or lake must not turn your road out of the way you desire to take, if it can be crossed by a bridge; and here is the great danger of inconsistency. If the scene is to be rural, the bridge should be rustic; if the presence of art must be manifested, here is room for the taste of the architect to be displayed, but the charm of rural scenery is destroyed at once. A rustic bridge can be made as strong as a fine architectural pile, and the less formality there is the better. However, we will begin by clearing the ground of all that must come away: let all the ditches and hollows peculiar to the old partitions of fields, paddocks, and enclosures, be filled up; the ground not levelled perhaps, because that may be contrary to the intended plan, but smoothed on the surface, which may nevertheless be uneven. In landscape gardening, there is not generally any more required of the levelling or smoothing than can be done by the eye and common level; and even the latter is in few cases wanted.

This preparation of the groundwork may be followed by forming

#### THE ROADS AND PATHS.

From the chief entrance to the mansion, there must be a carriage way, and this should be continued around the premi

ses—not exactly on the skirts, but so that the full extent of the premises devoted to the landscape may be seen: and it must, though it may lead to other entrances, be continued to the main entrance also. As the ground immediately adjoining the mansion is generally in high keeping, and sometimes laid out to correspond with the architectural lines of the house itself—such as a terrace the entire length of the front, with statues, vases, and the like, the landscape gardener's study should be to conceal all until you come upon it, and the landscape is shut out. But if the landscape style is to be kept up throughout, so far as all in front of the main entrance is concerned, the more formal portions may be still more isolated. In laying down the road, therefore, use stakes which can be seen at a distance, and mark out the plan by placing them in the centre of your proposed road; let it take a gentle sweep to the right and left of the entrance; not abruptly; but by an easy turn on each side, as soon as the road can be made to do it without inconveniencing the drive of the carriage. When we say that this road is to skirt the premises, we mean that it shall go in some places within twenty yards, and in others thirty or forty—the object being to give a large space of green. Where the roads part at the entrance, there must be a tolerable heavy plantation, both to prevent the view of the house and to form a reason for the roads diverging; for let it be remembered that, as nature gives a reason for the absence of straight lines, the landscape gardener must do the same. There must be an apparently natural cause for every turn. This is evidently the case, because trees, mounds, or water, or some other natural obstacle, prevents us from going straight, and the gardener has to create these natural obstacles. It must always be shown that the road cannot go straight: clumps of shrubs here, a mound there, water in the other place, are in the way of a straight line; and keeping this in view, the road may not only be sweeping round the estate on the dressed part of it, but it may also go here and there in a



serpentine figure, the hollow sides being occupied by some proper obstacle, which however may give harmony and grace to the view. Where the road forms, as it must in all of its turns, part of the segment of a circle, the inner side of the circle may be planted with shrubs, forming a clump close up to the road; but in any clump or figure that we may choose to adopt inside, to render the scene broken and yet harmonious, it is that we make a road serpentine, independently of its general direction, which would be round the estate, that we may plant on both sides occasionally; and, as we propose from the first to have a good space to spare on the outside between the road and the boundary planting, this plan of serpentineing, it affords great opportunity of varying the planting.

There is nothing which so much cuts up a ground and detracts from its grandeur of effect, as a number of roads and paths crossing each other. Beyond the main road, which at the least should be twelve or fourteen feet wide, and would be better if it were sixteen, leave all the inside space of park or park-like ground in view; if this be cut up by cross paths and other roads, without any excuse for them, the whole charm of the landscape is destroyed.

If there be other roads, and the space is sufficiently large to warrant it, let there be some temptation to use them. A lake is an object; so if there be a woody glen, a shepherd's hut in the rustic style of building, a boat house after the style of the fisherman's hut, or any other attractive object, a road may lead to it or past it; but plain roads, merely passing across plain pasture, are intolerable. There should, for good effect, be a spacious green lawn or pasture, for expanse is a great object; and although a noble specimen of wood may be tolerated, it is as unwise to cut up the space with specimens as with roads. If we must have other roads, let the same rule be obeyed; the road must not be straight, and there must be obstacles to cause its deviation: it would look silly to see a road in half a dozen differ-

ent directions over plain grass, without any reason for not going straight, because common sense would teach everybody not only to wonder why it went winding, but to give a practical lesson in his own person, by going over the grass the shortest way.

To set about making the road, when we have pegged out the direction—we mean to carry it, or rather cut it—let six or eight feet be measured on each side, according to the width it is to be, and let the turf or the ground, be marked with stakes on both sides the row of pegs put down; and, in measuring this, be exceedingly careful to measure at right angles; for if the rods used were sloped one way or the other, there would be less width marked.

A very easy way of marking it would be to take a line the exact length that will reach across the road, and let one man go on each side, and having a knot in the middle of the line, place it against the pegs, and each set down a stake or peg at the right place as to width, and tolerably close. The gardener should then survey his road before a turf is disturbed; and if he, upon looking and walking along it carefully, sees no awkward bends, but easy sweeps and graceful though varied curves, he may take up his centre row of pegs and have it dug out one good spit all over and thrown out; and the cart, which must bring stones or gravel to fill up, may take off the loam or top spit to fill up hollow aces, or to replace the holes that are made in digging gravel, or to improve mounds, or, if there be no use for it, let it form an artificial mound anywhere, to be removed when required. We are supposing the ground to be well drained, and especially the road part; for, unless the land is properly drained, half the money and labor expended on it are lost. This is the most laborious of all garden work; but unless there be a good foundation, and the road hard and dry, it is a nuisance.

After the rough stones and hard materials have settled in their place, a coating of finer gravel must be used, and

the whole well rolled down after every shower of rain. The road should be cut level, or nearly so, through all unequities; and if it ascend or descend a little all the way, the slope should be kept uniform. As regards the form in which the road should be left, it should be rising in the middle so as to throw the water off to the edges. If the grass on the land be good enough to represent lawn, or pretty even pasture for park-like grounds, such parts as may have been necessarily disturbed may be sown with grass seeds after levelling; but if the lawn has been for the most part disturbed, each side of the road should be levelled to it at the edge, and new turf edgings a foot wide should be laid along at the whole distance, and the rest may be good.

Paths are like roads upon a smaller scale; but in the larger features of the landscape they should never be less than six feet wide, that three people may walk abreast; and as the road is more especially for carriages, we may be excused for making a path go a nearer way to the mansion, but even in the necessary deviations to make it take a graceful sweep, we must not omit the obstacles which should be formed by planting, by mounds, or other contrivances; and in places it must go through, or between clumps of shrubs, close to the verges, so that there is good reason for carriages not going the same way; for this purpose the entrance to the path should be between the plantations, that it may seem to be what it really is.

If there be a lake, or a rivulet, or a river, it is well to make the path for some distance traverse its margin; or if there be any other object worth a nearer inspection, the path, or a branch from it, should lead to or past it; and if the grounds about the house be shut out from the general landscape, the path should enter it without interfering with the road; and the planting at the outlet, which in fact forms the entrance near the house, should be as plainly indicative of its nature and purpose, and so contrived as to be ornamental, and not so formed as to admit of any lengthened

view. These principles can be carried out on a small scale, or rather on a limited scale, as well as on a large one, provided there be room enough to give the desired width; but, if the space be too limited, it would be best to omit the path altogether, for however small a place may be, roads and paths should seem part of a large one, instead of being reduced in proportions.

#### TREES, SHRUBS, AND PLANTING.

We take it for granted that there are in places some trees, bushes and ornamental wood standing, and we now come to their appropriation. On the outside of the road we have already provided various widths of space which have to be furnished, or to stand as lawn or parterre, as the case may be; and, first, we have to see that palings, or any other fence, be quite concealed by shrubs as high as the object they are to hide; this must be done with shrubs obedient to the knife—common and Portugal laurels, yews and box, alaternus, Aucuba japonica, and holly, are among the most useful, because they can be allowed to grow up, or be kept down as well, and answer the general purpose by aiding us in appropriating or shutting out the neighboring premises. These shrubs, too, form a diversified and highly effective foliage. These are not to be planted close to the fence, but with room to grow. But this would be a stiff, formal, border, if confined to a row that would conceal the fence or palings; we have, therefore, to form an irregular belt. The planting may be brought out, twenty, thirty, or even forty feet, in some places, in a bold clump, with ornamental, deciduous trees at the back, and in the centre, consisting of laburnums, thorns of different kinds, gueldres-roses, chestnuts, acacias, and various kinds of oaks, planes, and other ornamental timber; some of them in one clump, and some in another. They should be so planned in the planting as to widen gradually in a graceful curve, and then swelling into a bold breast-work, form a circle of noble trees and shrubs,

but fronted with evergreens and returning inwards a considerable way back; so that, by commencing another curve twenty feet further, which should be sharper or shorter, the planting being brought out nearly as far as the first, and returning towards the boundary, and, as it were, dying off to nothing, there would appear a twenty-feet opening, which would not show its termination; it would seem to lead to other and more extensive space than really exists, and as the back would only be fence high, and kept so, there would no boundary be seen.

These little contrivances in planting a belt, are too effective to be neglected, and the entire stiffness of a boundary would be lost altogether. We greatly admire evergreens on an estate; and therefore, in the foreground of these swellings, as we may call them, we should "be lavish" in the use of the arbutus, various firs, arbor-vitæ, cedars, rhododendrons, berberies, hollies, plain and variegated, in all their varieties, and other choice subjects; as we traversed the road, then we should be able to diversify the planting, while winter would be as inviting as summer, because the leading feature—evergreen—would hide the trunks of the deciduous trees, which would merely tower above them, and lighten the scene. In the curves on one or other side of the road, we should recommend clumps to be occupied by a selection of one family of shrubs. The rhododendron would form a fine clump, magnolias a second, the arbutus a third, evergreen berberies a fourth, hollies a fifth, and so on through whole families. Thus the foliage would be diversified in the different assemblages, while in the very large clumps, we might indulge in a mixture with the deciduous trees in the centre, and various evergreens form the foreground. We need hardly say, that these things must be planted with due regard to their probable growth, and not be planted too thickly; for such gardens are not formed for two or three years, but for future ages. This is the reason for choosing subjects that will grow down in the ground as well as high

up; for the front, otherwise in a few years would leave us their bare legs, or stumps, which would not be very acceptable. The planting therefore requires, first, that we should know the nature and habit of all the things we plant; and, secondly, that we should use this knowledge in planting the tallest in the places where they would be most appropriate.

As we approach nearer the mansion, our choice of shrubs and trees may be more select; we may add azaleas, pyrus japonica, andromedas, and other choice subjects, because more in sight and more likely to be appreciated; and along every footpath we should be doubly careful not to have anything coarse. We should not indulge much in deciduous plants, unless they are rich in foliage, for the bloom of all of them is of short duration, if we except the bloom of a few deciduous magnolias. We have said nothing of roses, but they would undoubtedly be comprised in the shrubs and trees, as we come nearer to the house and by the sides of the path; and of these we should have but few varieties, and they constant bloomers. There might be a dozen kinds, perhaps, that would almost always be in flower; and these we should multiply instead of seeking a large collection. If twenty white roses and twenty red were always in flower, in a place that would accommodate forty, it would be infinitely better than forty varieties, of which thirty would be out of bloom from July to the end of the year. It is one of the most judicious things that can be done, to aim at possessing numerous kinds of anything that gives us flowers for a short season, instead of aiming to keep up a feature as long as we can. We hardly know a more discouraging fact connected with collections of roses, than the common result of there being at no time, but a month of summer, half a dozen to be seen in flower.

## HILLS AND MOUNDS.

Too often, for want of judicious arrangement, these features are sad blots. They are wanted for the deposit of the soil taken from the excavations, if there be any ornamental water, and as a receptacle for the accumulated rubbish that cannot be used elsewhere. Natural mounds may be considerably improved, but how, would depend on their extent. There are many mounds that require only planting, and some prominent object among the trees to excite attention and give effect. But in forming a mound, there must be an easy, graceful rise, corresponding with a hollow, forming part of the same outline ; and, as has been well observed by old writers, lands under the plough for many years, may be found with the hollows greatly changed by filling up, and mounds lowered by the loss of what has been in the course of time ploughed in the hollows. The greatest care will be required in this nice operation, which also involves large cost of labor. Let there be no attempt at a mound that appears insignificant. The impression that a lot of earth has been left, that should have been cleared away, is very awkward. There must be no abrupt rising from a flat surface, as is very often the case in manufactured mounds, as they are called in the dignified language of the guide books. Advantage must be taken of all that nature has done ; and it may frequently be improved by additions and changes—that is, by raising it in one place with all the spare soil, and what may be taken from other parts.

The top of a mound of sufficient extent affords, generally, a fine view of the domain all round, and sometimes of adjoining property. In planting such a mound, care should be taken, as the path winds round, to stop out from the view any object that is common-place or disagreeable, so that the best, and only the best can be seen. On such an eminence is the place for some **building**, which should be a resting

place at all times, and an agreeable apartment to spend a few hours in. A temple of some kind is most appropriate. It may be an imitation of a ruined building; but there is nothing looks more beautiful, when half concealed by trees than pillars supported by a classic façade or some well executed imitation of ruins, but not upon a small scale. If the walls are not three feet or more thick, and all things in proportion, better leave it for trees alone; for there is nothing more contemptible than the ruins of a nine-inch brick wall. The least appearance of diminutiveness is intolerable: better have a square lump of solid ruin, without any attempt at elevation, than lath and plaster castles, that will scarcely stand a puff of air. Let everything that is not common be on a gigantic scale, even if there be but little of it. A temple, if the front only were standing, composed of four pillars and a façade; and supposing it to be a ruin, the remainder only represented by a corresponding brick column and stones, would be effective, if partly concealed by thick trees.

The planting of a mound requires considerable taste and judgment. We must treat the whole as antique. It must be supposed to have been on the ground, and to have been preserved. Modern planting of rich beauties would not do for such a scene. Oak would be an appropriate subject for such a Druid's temple; but it is scarcely inappropriate for anything supposed to originate in a country where it is indigenous. Still there are many trees that would be more in keeping with many others. All this has to be kept in mind when we are making an object for other models. It would seem greatly out of keeping to plant modern shrubs as the adjuncts to an antique building; and it should be recollected that, if we could make a feature like this in all respects consistent, a great point would be gained; and, in the absence of this, in attempting anything great, we had better adopt at once the model of a rustic cottage. The principal aim must always be, not to attempt more than can be accomplished well. If a mound be simply planted and



no object beyond trees be attempted, the wood should be so mixed that the varied colors of the foliage, whether in perfection or in its decline, shall blend well; or, it may be that the holly, cedar, the spreading kind of pines, the yew and other subjects that acquire beauty and interest by age, may lend their united aid in forming a picturesque object from all parts of the ground.

But, if we have to excavate for a lake, we may dispose of the earth to advantage in creating a rising ground at one end of it, or for a certain distance along its margin; and no place is so fitting for rock-work; and if this be attempted, much depends on the material to be obtained for its execution. It is to be borne in mind, that hillocks, or small mounds, in different parts of a landscape, cannot be approved; and if this be the natural state of the ground to any great extent, we should at once determine whether all shall be levelled, and the excess of soil taken to the place where one upon a more enlarged scale shall be formed, or the superabundant earth should be taken to the hollows, to fill up and assist in forming something like an even surface. If the former, there must be some taste exercised in choosing the site; and if the latter, some care taken to lessen the work as much as possible by judicious disposition of the power at hand, to avoid going over the ground twice where once would do, and by carrying the superfluous soil of a hillock to the nearest place that may be available. Something will depend on the nature of the subsoil. It may be discovered that it consists of gravel; in which case, all the top soil must be saved for the surface: no good surface soil should be buried. It may be stone boulders, or mixed with large stones. It may be rocky; in such a case, there is a temptation to form rock-work on a large scale, and the material being on the spot, it would be comparatively less expensive.

It is from this importance of the subsoil that we direct levelling before road-making, because, if the subsoil be gravel

or stones of large size, the material for the road is ready; and if the stones be too large, they must be broken. Nobody in fact could attempt to move, in any of the operations, without boring and digging, to see where or how he is to find material for the roads, and enable him to determine what features of the ground he will preserve, and what he will destroy. Nearly all those authors who treat of landscape gardening, more or less liken it to the art of the painter, who can bring upon his canvas the beauties of half-a-dozen different spots, and yet make them all harmonize. But the material difference is in the execution. The painter can represent a mountain, a river, a waterfall, a cascade, trees of five hundred years growth, and rocks immovable; but the landscape gardener is limited by want of means, and cannot perform miracles.

There is as much difference between the painting and the reality as between a book of travels and the journey. The painter has no limit; his poetical imagination may run riot in his great works. He can bring the Ganges where the Thames only runs, and the Pyramids of Egypt as companions for the parks of Savannah. If he makes his scenery harmonize and forms a good landscape, it is all that is required; and the landscape gardener can do the same thing on paper; but in practice he must be guided by the scenery he has to begin upon and the improvements which are practicable. His mountains may require to be erected by cartloads; and for every hogshead of water his lake is to contain, he must remove a corresponding quantity of solid earth. Loudon suggests the study of landscape paintings, but undoubtedly the study of nature must be the gardener's chief means of instruction. He can form in his mind a tolerably correct idea of what he can imitate, when he looks on the reality; but if he once allows himself to be beguiled by the pencil of the artist; he may be deceived.

It is almost impossible to walk out in our woods and forests, without learning something practicable. The group-

ings of trees, the effect of broken ground, the commanding views from hills, and the rising ground from valleys, the turns of a river, now gurgling over a broad bed of rough stones, anon rushing in a narrow stream between high banks, and then swelling out into a broad and comparatively smooth lake—are all so many lessons in the art of landscape gardening. But in nothing do we find more instructive hints than in the various groups of trees, and the wooding of various mounds, some of which are covered, others only patched, but all more or less ornamented with foliage and verdure. From every one of these groups and mounds we may take a useful lesson. We may expand our ideas of variety and propriety according as the scene pleases or annoys us.

Although a valley is almost always the companion of a mound, or something more, we must treat of them separately.

#### VALLEYS AND LOW GROUNDS.

The management of valleys is just the converse of mounds; but we have to aim at great ones, for mere hollows, as if the earth had been robbed of its soil, are eye-sores, and must be got rid of. If, as is not uncommon, there is a hollow or valley running across an estate, it may be questioned whether it could be improved or destroyed. These are often wet in winter and almost a river of water; and if so, some means must be provided for getting rid of this by constructing drainage, before we can either fill up or break the stiffness of the line, if it be so. If it be a decided hollow, with rising ground all around it, the bottom must be the receptacle for all the rains and draining of the surrounding ground, and part of the year, at least, partially filled with water. This must be improved, or got rid of; an unmeaning swamp at the bottom of a hollow ought not to be tolerated. Make it water, if it cannot be drained; and if neither can be done, fill it up, as far as it is practicable, with stones and any

other rough material, and lessen the hollow as much as possible, by raising it in the middle, and at least forming a shallower basin, which will be dry, because it will drain into the rough stuff as fast as it runs down. But, presuming it to be of any bold and formidable extent, at once make a piece of water there by puddling it well as far as the water can reach, then drain all the surrounding land into it, and otherwise keep up the supply; give some consistency of form, plant the sides appropriately, construct a small boat-house which shall be ornamental, and plant with water-lilies and other aquatic plants, convert the banks or sides, at least along a portion of its margin, into rock-work, or adopt any means to render it a feature. But all small hollows must be filled up; there is nothing more objectionable to the eye than holes or lumps; and if the former have been made by excavating for gravel, or soil, or chalk, and present by their appearance and number direct obstacles to the filling up, there is nothing left for us but to plant and conceal them; whereas very extensive hollows, large enough to be turned to good account, may be made very interesting features; by breaking their perpendicular sides into fragmental ledges and rocky projections, by supplying them with appropriate plants, by reducing the bottom to some picturesque form, that which otherwise would be a blemish, may be converted to one of the most interesting features. It is impossible to convey lessons to meet such a case, because there are no two places alike in everything.

The design would depend altogether on the depth, the extent, the nature of the material, and the situation, all such places have roads sloping to the bottom, which have been used to draw out the material, and this road must be rendered picturesque by the breaking of the sides and planting them, by turning if straight, by widening if narrow. There must be some object when we get there—a gipsy hut, a hermits cave, a grotto, a fountain, or some other object, if it be but a garden seat, or the tomb of a favorite dog, or,

as Pope had, in his underground passage which communicated between the premises on either side the road, the busts of literary and bosom friends. Such a place might be devoted to some such purpose, and embrace memorials of departed great men. But all this is fancy; if the places are of noble size, and the banks or sides capable of forming extensively picturesque features, there would be no occasion for any half so gloomy.

Gravel pits are of the same nature as chalk or marl pits, or stone or slate quarries; the sides are frequently as perpendicular, but not so easily to manage; for they can be only made into regular shelves, or can even slope, whereas marl can be formed into anything, and slate or stone is as convertible as chalk, though perhaps not so easily worked. The planting round such places, to conceal them, often leads to accidents to men and beasts; and, if the soil be very dry, it is a question whether it would not be better to work away the sides into the bottom, and thus convert a dangerous hole into a valley, the more extended the better, although attended with great labor; all these things must, however, be taken into consideration before we commence, for indecision is fatal. Until we have made up our mind what to do, we must do nothing; and when we have determined, no ordinary circumstance should turn us from our object; not but our coming upon springs, or any other undiscovered change of character in our work, may induce, nay, force us to alter our design; but we must then reconsider, with the new circumstances in our mind, and not move again till we have again decided. We may have to form a lake, or a rivulet, or fall, where we did not intend, but we should never go on upon speculation as to what we shall do next.

#### ROCK-WORK.

We have already mentioned this subject, and pointed out some cases, where its adoption would be judicious. If we could command it, we should have water at the foot, that

there may be a seeming consistency in the picture, but, as this may not always be, and the work may in some cases be almost done to our hand, we must not lay down rules too arbitrary. The first thing to impress upon the mind, is the necessity of boldness, roughness, extent; for the idea of rocks which a man can stride over—and this may often be seen at public nurseries—seems to us to be the height of absurdity: a rock should be noble; if a man of taste has not to look up at it, he will indeed look down on it; it is as contemptible as a doll's-house, or a child's plaything; too diminutive, to show what it is meant for, it looks like what it is not meant for, and nothing can be more paltry. We have said before, that rock-work may be made of any size, from a barrow full of stones, thrown down on a heap, to the rock of St. Elba; but this was in allusion to its adaptation to plants. A rock made of two bricks will do to nourish, and yet to supply the necessary drainage to a plant, as well as if they were heaped mountains high; but in reference to landscape gardening, rock-work should be twenty feet high or nothing; the only excuse for anything lower would be to cover a mound with fragments of bricks, flints, stones, and slates, and each appear like the rock merely protruding through, which, when covered with plants, would look better than any paltry elevation. But rock-work is one of those features which are not necessarily part of a landscape gardening, and unless very judiciously managed, and of a respectable extent and elevation, is far better omitted.

The temptations to construct rock-work are, first, the presence of abundance of appropriate materials, which would be in the way if not appropriated; second, the presence of water, which is one of the most important adjuncts; thirdly, portions of highly broken mounds, easily convertible into rocks, so far as the surface is concerned; fourthly, the presence of excavations of any kind, not easily convertible, nor without immense labor filled up; lastly, the presence of a deep valley which is to be retained. Any or all of these

circumstances, naturally tempt one to introduce rock-work; and, in constructing this, the evils to be avoided are, first, diminutiveness, than which nothing is so destructive to the harmony of the picture; second, smoothness, which detracts from the grandeur, if not absolutely from the natural appearance of the rock; thirdly, choosing a bad place; fourthly not attending to the surrounding, or at least the adjoining scenery. A rock built up in the middle of a lawn or a park, would look exceedingly ridiculous alone, but a rocky scene on the margin of a lake, might look perfectly natural; the place should be a gradual, hollow, slope from near the ground upwards, the outer surface being made with chiefly very large fragments of stone, or material in imitation, so as to form a bold, rugged face; and here let it be above all things remembered, that rocks are not in nature formed of lumps of glass, bits of carved stone, broken ornaments, and such like, as one would imagine they were from looking at scores of garden establishments; they are either chalk, or granite, or quartz, or sandstone, or some other distinct material, and their fragments are all of the like character, although not two may be of the same size or likeness. We have seen a very distinguished amateur rock-work, which has been so managed as to evade the responsibilities heaped on us by the second commandment; it is like nothing on the earth beneath, nor the waters under the earth; patched up as children make grottos—not those with oyster shells, for they are at least all alike, but those which ingenious youthful architects make with glass and beads, bits of coral, and so forth, as if—and perhaps it is so—the value of the building were to be estimated by the variety of materials on the face of it; and when we expressed surprise, we were directed to a dozen more in the city, some in houses, some out of doors, but all looking excessively small, and very ridiculous. This, therefore, above all things, should be avoided, and we earnestly beg some of our most distinguished amateurs to blow up their rock-work, as soon as they wish to get rid of the

responsibility of enforcing by example a very bad taste, shown under the auspices of very fine plants and very good establishments. The plan of a rock requires as much architectural taste as the plan of a house; let the crags and interstices preserve a character as if the rock were real; beauty, as some people would call it, must be sacrificed to propriety. We would rather see rock-plants growing upon the imitative ruins of a broken-down castle, than upon some of the so-called rock-work that graces very high places. There must be no outside contrivances, no back that is not fit to be seen, no blemishes to be hidden by plantations; what is proper in one place is proper in another, and the only varieties that should be seen in the different faces of the rock, should be only such as could be seen in nature. Avoid all puny rock-work; countenance nothing but that which will be creditable to size and character. In excavations, where the side of chalk-pits, or stone, or slate-quarries, are almost perpendicular, these sides must in part be broken down to a slope of crags, leaving a portion upright just where it may seem to aid best the general effect; and the falling of the sides, as they are disturbed, will almost form the work without the labor of a mason or the architect; at all events, the work will be greatly facilitated.

When rock-work is constructed by the side of water, a path must be made at the foot, or there must be some standing place, unless it happens that the water is so constructed as to enable it to be well seen from the opposite path. On this account it is better to carry out a sort of bay, round two thirds of which the rocks can be so constructed as to form a kind of rough amphitheatre, so that those standing at the entrance, or near it, may see pretty nearly all without going nearer. There must be no uniformity in the construction of the rocks, and the plants selected for them must not be the diminutive little alpine that you must be close to before you can see, but for most parts the bolder kinds, which are a feature in themselves, and such of the



smaller ones as are covered with bloom; and, as there will be great fissures provided, as well as dry and shallow receptacles for soil, even shrubs and trees of appropriate kinds may be planted and grown to advantage. The tops of the rock-work must be composed of bold crags here and there, and the outline must be broken by gaps; some of the pieces should be broad on the upper part, and form wide shelves, and in all parts the features, as it were, should be large. On the land-side great attention should be paid to the natural construction, and the lower part, near the ground, may be strewed with fragments, among which plants of various sorts should be growing. The crags may be also bold on the land-side, and the plants from top to bottom equally choice and varied. If a mound forms part of the height on the land-side, it is perfectly natural, as in mountainous places the rocks protrude sometimes half-way up, and generally in patches, up the whole face of the mountain; and so also with smaller hills and rising grounds; but all this will be very trumpery if done on a small scale.

With these general remarks, our friends who are desirous of making rock-work will be able to set about their work with right notions; and many who think they have rock-work, because they have a few clinkers and flint-stones piled one above the other, will be as anxious to destroy the vestiges of some party's simplicity. If we have not the means of forming proper rock-work upon a scale of sufficient extent, the next best plan is to have it built with bricks, but still to adopt a style of some kind; but always—for we cannot impress this upon the mind too deeply nor too often—make it large enough or not at all. An artist of some celebrity in imitation has recently completed a jumble of something between ruins and rock-work, and we hardly know what to call it; we cannot call it rock-work, because there is nothing like rock about it; if a nine-inch brick building had been melting away instead of tumbling down, and when it was half melted suddenly congealed again, we might, by a stretch

of fancy, consider the work in question a representation; but it has melted holes in the walls, and these are furnished with little white heads that seem looking out with astonishment at the change which has been wrought. A shell or two, here and there, looks as if somebody had been pelting the inmates while the walls were in a state of fusion, and they had stuck there. And this, be it mentioned, had been executed by an artist in rock-work, for a gentleman who held him to no price, but wanted good rock-work. The heads and shells do not match each other: if the head of old Neptune had been looking out of one hole, and a mermaid's head, with her comb and glass, had figured at another, they might seem at home among the shells; but to see Mercury and Milton at the holes in the wall, seems perfectly *outré*. We have digressed, because to show up prevailing faults is no bad road to improvement; and we have not told people what we dislike, without also telling them what we approve. We may, however, be wrong after all, and particularly if, as we are told by some, landscape gardening is subject to no rules, and cannot be reconciled to any principles, but depends entirely on the taste of the gardener; for if so, all we have done yet is to show that our taste differs very materially from that of many other persons.

#### OF WATER, AND ITS APPROPRIATION OR ADOPTION.

If the ugliest and poorest stream of water runs through grounds that are to be laid out or improved, it is certainly convertible to ornamental purposes. It is not necessary that water should be deep because it is wide, or that the supply should be bad because the stream is narrow; but the plan of boring for water is now reduced to such a system, that it is only a question of expense; and where a supply of water is short or doubtful, it is better at once to provide it. But many streams, however small, may be made ornamental by first opening the bed of the water, or rather the channel, to a proper ornamental figure, widening it where desirable, and

so adapting the outline to the place and plan of the work as to secure a picturesque and natural appearance. But it may be, and generally is the case, with streams that are insignificant in appearance, that it arises from the too rapid descent of the channel. In this case, begin by damming up the lower part, where it leaves the ground, high enough to fill up to the banks there; and as that may not fill it, a long way back other dams must be placed across higher up, to fill it there, and so on, that it may form a series of smooth water and falls, entirely through the ground. All these falls may be made ornamental; that is, a bed of stones on the lower side of the dam may be piled up against it, and made perfectly solid, that the water, little as it may be, shall run over the surface, and not be lost to appearance by sinking into them. They can also be made rugged, and portions of them reach above the dam to drive the little water there is through less openings. Nor need the stones be in a line across the river; they may imitate a natural barrier; but it need not be mentioned, perhaps, that whatever width the bed of the river be made, so that the bottom be puddled and the sides made to retain water, the stream will fill it, and then allowing for increased evaporation and waste, the supply will go over at the bottom; so that a very inconsiderable rivulet will be readily converted to a respectable river, and perhaps may be aided very much by tile-drains from the higher grounds, run diagonally into the stream; or if more water be absolutely necessary, we must resort to boring.

All rivers are capable of improvement, or the grounds that immediately join may be so managed as to greatly improve the appearance. The most awkward to manage are those whose bed lies very much lower than the banks. Here we must resort to damming up the water as before mentioned but presuming there is a good supply, it will make a respectable cascade at some—the best adapted—part of the ground towards the lower end of the stream. But it may be that the river turns some mills, and that there are other obsta-

cles to the damming up of the water; in this case the ground must be lowered near the sides of the river to the water's edge, and be gradually sloped off to make an easy sweep down to the water, that the view may not be hidden by the banks, which would naturally conceal the river from sight at a very small distance. In this case the slope ought to be carried to a considerable distance, say twenty yards, so as to be able to avoid all appearance of abruptness, and show the whole width of the stream a long way before we arrive at it.

It is quite reasonable to suppose, that water is too great a treasure in a good domain to be lost for want of some care and expense, and that all the means of preservation would be used that could well be applied. Now, presuming the water, as in the first instance, to be scanty, every little that could be returned to the head of the river would be an object. By applying the water-ram (an ancient implement, but now rapidly coming into use,) at the outer fall, a considerable quantity could be sent back through pipes some hundred feet; and as the instrument is self-acting, the only expense is the first, and the greater the fall at the lower end of the stream, the more powerful and effective will be the ram. We have seen this simple instrument the means of forcing water to the top of a house, to supply cisterns for all purposes of the establishment.

But it may be that there is no water, and that we have to form an ornamental lake. Let the size be in proportion to the work all around it, not a mere duck pond, but more rather than less than can be afforded for the space under management, for nothing can be more ornamental. We remember once being betrayed into making a mere pond for gold fish, and unfortunately instead of its being among the avowedly formal part of the garden, it was placed on the lawn, which was laid out with its roads and plantations in true landscape style. As it was a brick and cement affair, thirty feet by fifteen, there was no moving it; but we were

soon determined to plant it out as a nuisance, instead of pointing it out as a beauty. Such things are not for landscape gardens; they are for parterres in the neighborhood of architectural beauties, and not for rural gardening. Nothing could be more paltry, nor was there anything about the place of which we were so much ashamed. Let your lake be of any odd shape, or no shape, if you please; not with angles and corners, but such outlines as nature gives us in her ordinary works. Study to avoid formality, and make the excavation from two feet on the sides to six, or say five feet in the middle. If you come upon soft places, go deeper there, in the reasonable hope of coming to springs; for a supply of water is a most important part of the affair. According to the nature of the ground, so must you determine to puddle the bottom and sides, or otherwise. If you are digging in clay, it will retain the water; but if in gravel or sand, or loose soil, the entire bottom as well as sides will have to be puddled, unless springs come up through the sand, and fill your pond. But it frequently happens that springs will fill your pond up to a certain part, and that the loose ground takes it off there—in short, that no supply will keep it above that mark, which may be a good deal too low for appearance or use. Nothing but puddling can avail us in that case; and puddling may be explained to be the making of a lining with well-kneaded clay. If we are obliged to supply the water from other means, it is but to confine the depth to about four or five feet at the deepest part, and two feet on the sides, but of the saucer form of hollow, and then putting well-kneaded clay all over it, and setting men with rammers to beat it, or rather run it out into an equal bottom of about nine inches to a foot in thickness; for well-worked clay is as impervious to water as if it were baked. This puddling is to be worked up the side to the very edge, and it will then retain all the water that is put into it, except what goes off by evaporation. As, however, lakes must be made at the lowest part of a domain, and all the

land around may be drained into it, we are seldom compelled to puddle any more than the sides, for a few feet in, all round. We should never choose an estate without water, and we should lay out the whole of it, even choosing the site for the house with some reference to a good view of a part, if not the whole of it, though it would enter into our plan to conceal it here and there by planting, to break the line of the edges of it; for we can conceive of nothing more naked than water without wood.

#### FOUNTAINS.

These belong to the formal portion of gardening, but the making of them may be treated of in this place as part of the management of water. We need hardly inform the amateur gardener, that neither fountains nor falls can be produced without a head of water; and this must be either supplied by the nature of the place, or by force-pumps. If we possess the head of water by means of springs on high ground, the construction of the fountain is simply by means of a pipe to convey the water to the lower ground, where the jet of the fountain is placed; and here it may be necessary to hint, that the lower the design is formed—that is, the nearer it is to the water—the higher it will play. But if we have to form the head for the purpose of the fountain, the nearer it is to the work it has to do, the better it will be done. Generally, it is by means of a large tank; and the water is pumped up by horse, or manual, or steam-power, from this tank, which should be concealed, or be placed on the top of some of the offices, so as to be a part as it were of the building; the same head of water may be made to supply the mansion. Where the water is supplied by power, the fountains need not always be playing; but, with a natural head of water, it is of little or no consequence. Fountains are as various in their designs as any other object in a garden. They may be made to play in a circular basin where gold and silver fish may be seen sporting, or they may

be constructed so as to spirt or run from grotesque figures. Lions' heads vomiting water are common; but the most unmeaning and senseless subjects are as common as anything; thus, a figure spouting up the water from a horn—one would think the imagination poor indeed that could not find a better subject. A dolphin, or any other water monster, spouting up water after the fashion of a whale, and whose figure would be half out and half in the water, would seem more natural, and it would have the advantage of being closer to the power. For be it remembered, that if water will rise ten feet, every foot that is taken away by the pedestal and figure has to be deducted from the jet. Therefore anything close to the water's surface will give us all the power in the jet. Boring for water in some places forms a powerful fountain. The gutta percha tubing is now preferred to lead, and can be used at any length and for any period underground without corroding.

#### GENERAL OBSERVATIONS.

We have shown, we believe, pretty clearly, that, without questioning whether formal or landscape gardening is the better, we cannot tolerate a mixture. In landscape gardening there must be no straight lines, whether it be water, or grass, or roads, or paths. There must be nothing in rows or straight lines; whatever is to be formal or contrary to nature must be isolated, and not form part of the general scene. We have no objections to urge against geometrical figures and fancy, uniform flower beds, but they must be in a garden shut out from the landscape; and, indeed, so far do we approve of them in their places, that we think nothing so good in a proper flower garden, of which we have yet to speak, or rather write. The conservatory should, if possible, be so contrived as to be entered from the house, and have its outlet in the flower garden; but we would have neither seen from the landscape. Let private walks, into which the passer-by on the landscape cannot see more than a few feet,

lead to the beds of flowers and fanciful gravel walks. Let there be terraces, statues, vases, and all kinds of garden ornaments, if you will, to be seen when we arrive, but let it burst on our view as we emerge from our branch walk. Let there be circular, oval, square, octagon, or oblong houses; fountains, and fancy flower-pots, all very delightful in their places, but keep them in their places. No mixture can be consistent with good taste; at least, such is the impression which we have, and are likely to keep. We only want things called by their right names. A landscape cannot be a geometrical figure; and for an avowedly artificial garden, order and uniformity can alone be tolerated.

#### FORMAL GARDENING.

This, in contradistinction to landscape gardening, is every way artificial. Every bed, border, clump, or gravel-walk, is formed according to some order or regularity of figure, and all is uniform. It applies to those parts of a garden which are devoted to flowers, be they where they may, and in most places some portion near the mansion, or the conservatory, or the summer-house, and is thoroughly distinct from the landscape, if there be one; or it may be that the whole of a domain is thus artificially planned—straight avenues of trees, straight roads, straight canals, all are in keeping with each other, and order and regularity, and even uniformity is preserved throughout. The leading features in formal gardening are terraces, statues, fountains, avenues of trees, bold but straight walks and roads, and canals with straight banks; and circular pieces of water, formal cascades as if the water were running down a flight of steps; angles, circles, squares, and straight lines, proclaim, at every step we take, that the work has been accomplished by the hand of man. The ordinary architect would succeed in laying down a plan quite as well as the gardener; and there is no doubt but the builder of a mansion would carry out ideas suited to the elevation as well as any professional designer



of garden plans. All things appertaining to the plan must be adopted according to the architectural taste displayed on the building. Terrace-walks should be parallel to the front or sides. Here expanse is exhibited by the length of walks, roads, and avenues, and these must be upon a scale suited to the elevation of the building. The ornaments to terrace-walks must be in keeping with the style of architecture. Where there is an immense long walk, and space on each side, there should be circles every forty, or fifty, or eighty yards, the segments of which, on both sides, should be ornamented with seats, and the centre may be a basin for gold fish, a fountain, a temple, or some other device, not sufficient to interrupt a view of the entire length, but enough to break the monotony. The planting on either side should be perfectly uniform; whatever shaped bed, whatever kind of tree or shrub may be placed on one side, should be also placed on the other, and there is no rule for the construction of the edging. In formal gardening it may be stone, or box or grass; so that it be uniform, it matters not what. Rock-work, in this kind of gardening, may be as formal as a rough cone or pyramid, so it be in uniform situation. Here it would be as bad taste to see water of irregular shape, as it would to see a straight line in a landscape; therefore, unless a piece of water be of too large a space to see the extent, or observe the figure, it must be altered to round, or oval, or square, or half-circle, or some regular figure corresponding with the scenery adjoining. Walks and roads should lead to some object. The most simple and appropriate perhaps is a gate or entrance; and so necessary is this, that we have abundant instances of costly, but useless gates at the ends of avenues, which gates are necessary as ornaments, though they may never be opened; but there is a good reason for the adoption of gates—they afford an opportunity of displaying architectural taste; and we may find another good reason in the idea they convey of space. If the gates had a solid brick wall behind them, or were not even made to open,

they give one an idea that there is something beyond, where as a temple appears to be a finish. It is impossible to set bounds to the fancy in working out figures for beds on each side a walk or road; two or three points must, however, be kept in view. Angles must not be too small; the great fault of many formal gardens is that figures are attempted on too elaborate a scale; they look well enough in theory, very pretty when empty, because we can see every little turn and corner in the figure, but put plants in only six inches high, and the figure is lost. Let all figures be bold, simple, and easily seen when planted. There is no mistake in a circle, or half circle, or square, or oblong; but what sense would there be in an octagon? the straight angles would be lost when the plants grew, or when we were at a little distance. In like manner, any very sharp angle would be lost as soon as the plants grew up a little. Whatever, therefore, be the design, some care must be taken to use no figure that could not be seen to advantage, and always to adapt it to the height of the plants to be grown there. The road up to the entrance of a mansion should be the segment of a circle, for the sake of convenience, or the entire road from the entrance might be a whole circle; but the back-front of the house is the place to display taste in the terrace walk. The garden at the back may have an entire walk of four straight sides going completely about the space, or at least so nearly as brings us within sight of the boundaries; or there may be a square space enclosed as it were by four straight walks, or the entire space may be compressed by a terrace walk the whole width, parallel with the back-front, and other walks uniformly diverging to the extent of length, with avenues of trees or shrubs, and terminating with some object; and in these avenues there may be statues, fountains, sun-dials, or whatever other devices may please the taste. There should, however, be grass, or flower-borders, or both, on each side these walks, planned uniformly and planted uniformly. There can be no set rules for the laying

out of a formal garden; but there are some points worth considering. If, for instance, we have an avenue of trees in a garden, it would be most desirable if we could make an opening through all the wood in the adjoining premises, because then the effect would be so much more grand.

Whenever a walk is very long, there should be breaks where seats could be placed. If we have to put a gate at the end of a walk, to give an idea of space, let the walk terminate twenty yards before we reach the end of the grounds, and let a cross walk appear on the other side of the gate; or, if it be preferred, let all beyond the gate be lawn or grass, and planting conceal the boundary, whether it be palings or wall. In formal gardening there is frequently used what is called a ha-ha fence, the object of which is to prevent a view from being interrupted by a wall or common fence; this is made by digging a trench five or six feet deep, and building a wall up to the surface only, and outside the wall the earth is removed altogether in a sloping direction, so that on the outside any one may walk down the slope to the foot of the wall, and there he is as far from getting in as he would be if the wall were on the surface, and as much above him. By means of this ha-ha fence we are enabled to appropriate the land beyond the fence to cattle, or to any other purpose, without having the space confined, or the view interrupted by a wall above the surface.

In planting these formal gardens, the greatest care must be taken to plant such trees and shrubs as are adapted to keep up a uniform growth, because, unlike the landscape, where the difference of growth and foliage, however uncouth that growth may be, in some cases rather heightens the natural beauties of wood, the formal garden wants uniform growth; a mixture of wood, unless it be a uniform mixture, would destroy the harmony and keeping of the place—a clump of shrubs on one side must be opposed by a like clump on the other; rhododendrons should not only be put opposite rhododendrons, but the like kind of rhododendrons; and,

in the management of these uniform clumps, the knife **must** restrain the too vigorous growth of any that by exuberant shoots bid fair to spoil the uniformity. After things have attained a tolerable size, and got well hold of the ground, these will not vary much. The clumps of flowers, or rather the flower-beds, must not only be uniform, but they must be furnished in a uniform manner. If there be a round bed on each side, they must be filled with flowers of the same kind and color. Nine-tenths of the geometrical gardens are spoiled in the planting; for, even in the instructions which some flower gardeners have published, there is a direction what to grow in each compartment, without the slightest attention to uniformity of color; and we have recently been through a garden where the beds are uniform and not even the colors alike. This borders upon downright ignorance of principle, because if we desire uniformity—which we show we do by making the beds uniform—it should be carried out by planting the same things in all corresponding beds. If, for instance, we have a round bed on each side of a path, and all other things are in uniform order, what sense is there in putting a patch of blue flowers on one side and white on the other?

In planning geometrical gardens, the compasses will do all we want, but in uniform gardens we may make all sorts of strange figures. We have seen ideas taken for patterns by first doubling a piece of writing paper, then with a pen scribble any kind of figure on one half the paper, and when it is wet, close the other half on it—the figure will be doubled, and of course must be perfectly uniform. This is a very simple thing, but well worth the attention of everybody who has to do with uniform patterns. But formal gardening is not confined to great places; there is scarcely a suburb of a town in England but contains houses with gardens on too small a scale to be anything but uniform. A square space in front, with a half-circle for a carriage sweep, is the proper description of thousands of villa gardens. But formal gar-

dens especially belong to the whole race of florists, that is to say, the cultivators of florists' flowers; and as this concerns thousands, we will take from the first the laying out of a florist's garden, and the gardening required to keep up a good stock of florists' flowers; for there is not anything in the whole routine of gardening that requires more care, or that until very recently was so little understood. Formal gardening especially applies to the cultivation of those subjects which have been improved on, those breeds which are grown in collection under name. And, first, let us look to the requirement of the florist. He must grow everything in beds or pots. Every individual plant has its name, and is known when in flower to the true florist as well as a man would be. Most of these favorites are cultivated in beds. Pinks, pansies, tulips, ranunculuses, anemones, verbenas, and many others, are uniformly cultivated in beds four feet wide. A true florist's garden, therefore, is best laid out in beds right and left of a centre walk; and if he wishes to be neat, he will have two-feet wide paths between, so that he can turn right and left anywhere, and work among his favorites without treading on borders. The centre walk ought to be six feet wide, and the beds, which should be laid out at right angles on both sides, must be four, the paths between eighteen inches at the least, but two feet if the ground can be spared. The length of the beds should be about twenty-five to thirty feet in the clear. Now, as four feet on the path end of the bed should be devoted to the path, that is to say, to plants which should form a border of flowers on each side, although in reality intersected by the narrow side-paths, they would require to be four feet longer on that account; but the length is necessarily governed by his space; it may be that he has not enough ground to make such length of beds, therefore the length we have mentioned has reference rather to large than small gardens; for we follow up the subject by mentioning, that if the width of the ground is considerably greater than will make such beds as we men-

tion, we would have other paths parallel with the middle one, so as to make two beds in width on each side instead of one. Suppose the ground to be anything under eighty feet wide, we would have a three-foot wide path down each side, within three feet of the boundary, so as to form a three-foot wide border all round the garden; then a centre walk of four to six feet, and paths of eighteen inches to two feet right and left, so as to lay the whole out into four-foot beds, the length which the ground would allow. For instance, if the ground be eighty feet wide, the six feet for the middle path, the six feet for the borders, and the eight feet for the two four-foot side-paths would occupy twenty feet of the width, and leave all the beds thirty feet long; and by occupying the four, or say five feet with plants, to give effect to both sides of the centre path, twenty five feet length of bed would be left for florists' flowers.

If the ground were considerably less than this, the beds would be proportionably shorter, and one would feel inclined to lessen the width of the paths to make the most of the ground. In these beds most of the subjects would be planted six inches apart, and therefore seven rows in a bed taken lengthwise—although florists count the rows the other way always, and say so many rows seven in a row. This is the most compact width for all kinds of operation. We can reach two feet across without inconvenience, to weed, plant, prune, or do anything else to whatever the bed contains. These beds are equally convenient for all things, even dahlias and hollyhocks, the two largest and most unwieldy things we have to do with, would be at proper distances one row down each bed, or of hollyhocks perhaps two rows, as they do not spread so much. But the very formality of the florist's garden, which would be neatness itself, should be kept up in the planting. A pink bed on one side should not be opposed by a pansy bed on the other; nothing would look worse, although we have often observed the florist to be too much taken up with the flowers individually to look

at his garden as a whole; and therefore in too many instances he is neat only in the beds which occupy his attention for the time being. His pinks, pansies, tulips, and other flowers occupying the beds, may be neat and clean, but the beds unoccupied with flowers are often neglected and over-run with weeds, whereas they should be the most clean part of the garden, on account of their being empty and having nothing to set them off. A space must be cut off, and put, as it were, out of sight, by planting, or by some other means; for the florist must have his heaps of composts and manures, his shades, glasses and pots somewhere out of sight. All the formality and uniformity in the world will not serve him, unless he can put what may fairly be called rubbish out of view.

We would next install the florist in his ample garden, formal though it be, with a tolerable collection of all the principal flowers.

#### PLEASURE GROUNDS AND FLOWER GARDENS.

There is nothing less understood among ordinary gardeners than the disposal of ground to advantage by the laying out of those portions which are nearest the house with a view to ornament. Men generally apportion their walks and groups of shrubs and trees according to the size of the ground, as if the persons who walk about could change their size to fit a narrow way. It cannot be in good taste to attempt more than can be accomplished well. All large estates, even forests themselves, have beautiful spots, and we cannot do better than imitate by art, in style at least, whatever is beautiful in nature. If we attempt in an acre of ground to produce too many features, we spoil them all; for inasmuch as none ought to be insignificantly small, many would so crowd the place as to leave no expanse for lawn; and if the features are imitated on a small scale, everything looks poor and babylike.

If you want a summer-house, let it be of a size that a

party can enjoy themselves in; not a pimpled cupboard of a place, with scarcely room for a table and chairs. Choose an appropriate place for it, generally a spot that commands fine views. Let it be raised a step or two, or even more, if there be any object in it. Place it close to the boundary, that the space before it may be as large as is practicable. If you can find pillars of any architectural beauty, and a portico-like top, it will be the most effective model you can take. If you have to build it new, pilasters will be cheaper, and, if not quite so effective, at least neat and elegant.

The next object is to form the path round the garden, as near the boundary as you can well bring it, so that you do not prevent the ordinary means used to conceal the extent. The outer portion of the ground always requires to be planted well, but so form these borders of shrubs as to give variety to the scene. If the garden be square, and much confined, it will cause some trouble; but let not the path be conducted in sharp corners or elbows—a graceful turn at all points, and nowhere abrupt. The borders must not be carried in the same line as the path; the verges should be of turf, a foot wide at least—the border unequal in width, and the path sometimes approaching it, at other places receding from it—the border sometimes showing a projecting breast-work of fine shrubs, up close to the path, at other places leaving a wide space of green turf, like the middle portion of the lawn. The path should not be less than six or eight feet wide, and the centre of the lawn should be clear of all specimens or beds; for there is no means of showing space off to so much advantage as the keeping as much of it within the range of the eye as possible. It is almost impossible to set down any rule, because scarcely two places present the same objects, the same means, and the same features. Clumps should never be farther from the edge of the path than the width of the verge which is left anywhere. Whatever size you have your bed or clump, whatever form it is to assume, the portion next the path is to be cut to within the foot



verge, and never should there be more or less width of verge; consequently, all the fancy form must be away from the path, that is, the side opposite the path.

Clumps may be of any odd form, any whimsical shape, without destroying the general effect, if attention be paid to the narrow verge, and it be kept the same width wherever the bed or clump joins the path. The corners or breaks in the outline of the beds suggest good places for specimen plants and shrubs, which should only be sufficiently removed from the path to secure room for their proper growth. Trees in the centre, or far away from the path, are blemishes; and if there be no other reason, specimen plants should be seen well without going out of the gravel walk.

On the side of the path next the boundary, breaks may be formed with clumps of roses, or American plants, or even flowers, that the outer border may not be so formal. By a receding of the clump towards the corner, the real boundary may be so concealed that it is impossible to tell whether there are ten yards or ten acres round the corner; and these contrivances, varied a little, but to the same effect, give an appearance of far greater extent than there really is. It is perfectly immaterial whether this leads to a statue or a seat, though we always prefer the latter; it is more useful and appropriate than any statue. Small beds or clumps cut in the grass, between the path and the border, help to break the line still more. We need hardly say that the boundary border of shrubs ought to be higher than the fence, whatever that fence may be, because the appearance of a fence or wall completely upsets all attempts to conceal the real extent. The greatest evil that most men fall into is the cutting up of a lawn by planting trees and making beds away from the gravel walk, and this makes us the more desirous to press upon the mind the impropriety of all such work. It may be permitted to put a circular basket occasionally near the mansion, and form beds to imitate baskets of flowers; but even these should be carefully and sparingly adopted.

A flower garden may be formed as mechanically as you please, of any pattern that a pair of compasses twirled about twenty ways will suggest; but they should always be adopted in isolated places out of the general landscape—in some favored nook that we may find.

So far as it can be accomplished, all ugly or formal buildings should be planted out. Greenhouses, and other horticultural buildings, often form no exception; for they are occasionally great obstructions to a fine bit of landscape. The road being kept wide, and the borders planted in proportion, the clumps that join the path at intervals on the inside or outside—that is, towards the border or towards the centre of the lawn—must be made large in proportion; so that, when the shrubs grow up to a reasonable size, the proportion shall be in accordance with all the rest of the plan. Nothing looks so pining and ridiculous as small clumps; and, except here and there in a favorable position for a few flowers, none ought to be made less than from ten to twenty feet across; because then you can form a rich clump of shrubs, and have flowering deciduous trees in the centre.

All pleasure grounds should be planted with evergreens; the entire features should be evergreen—as much varied as you please, but still evergreen. Deciduous trees should only be at the back of the others, or surrounded with them, so that in winter time the place should look as well clothed as in summer. It is possible, by these precautions, to make an acre of ground look as if it were part of a large domain instead of a limited space, whereas, if the path were four feet instead of six or eight or even ten, everything would strongly betoken the smaller space. We have seen, in an acre of ground, a little cottage, a very small conservatory, a greenhouse of the same diminutive kind, the imitation of a small chapel, stables, picture gallery, rock-work, fountain, and twenty other things, all cramped and inconvenient, and every way worthy of children instead of grown persons;

plenty of taste in miniature, but unworthy of anybody of expansive mind, and perfectly unnatural; whereas, if the contriver, who was so ambitious to imitate everything, had been content to make all his space match some pleasant portion of a larger estate, there had been something to admire and think of afterwards—something that would bear looking at. It is quite possible to adopt some other feature, but nothing should be attempted upon a small scale; it only destroys the grand features of the landscape. For instance, if there be any appropriate place, there might be rock-work; or if there be facilities for water, there is nothing to prevent its being done; but, unless it be done upon a large scale, it is labor wasted to spoil the scene.

Straight paths ought, under any circumstances, to be avoided in the pleasure grounds, if the landscape plan be adopted; and portions of the house should be planted out as well as any ugly object; that is, the shrubs planted near the house in clumps should be so placed as to break the straight line. If the house happen to be on an eminence, a terrace walk is not uncommon nor inelegant; but the planting of the front below it should be so contrived as to hide all the formality, and this can only be done by forming large clumps at appropriate points. The main path, too, should be carried round quite independent of the terrace walk, and removed far enough to allow of planting between them, so as to conceal all the stiff outline of the terrace-walk, and keep up the landscape character of the principal lawn and shrubbery.

Of course, every place has its peculiar capabilities and disadvantages, and we must always be guided a little by circumstances; but the main object—that of making the place appear as large as possible, or, in other words, to make the most of a small space—must be kept in view.

The principle on which landscape gardens is conducted properly, is that which pervades the most beautiful spots in nature. Landscape gardening is the art of imitating as

many natural beauties as possible in a garden, and following nature strictly as a teacher; hence we have no straight walks, no square-sided canals. But, inasmuch as nature furnishes us with a reason for crooked roads and winding streams, we must take care and imitate the cause of the deviation as well as the deviation itself. The paths pointed out for us on swampy ground, are the highest portions; the road marked out for us in a mountainous country is round a hill rather than straight across it. Nature, therefore, always furnishes us with the cause of deviation; we cannot go straight through a forest, nor straight over a mountain; we cannot, or rather we will not, go through water while by walking further round it we can keep dry. Water itself winds a devious course, because it will keep to the lowest ground. Pour a jug of water gently on the ground, even where you think it level, and you will soon see that the slightest inequality will cause it to turn aside. In this way have rivers been formed; and there is hardly anything more picturesque than the winding of a river, where there is also grass and wood to help the scenery. Now there is nothing here but what can be imitated; but it is better let alone than attempted on a small scale.

We may be told that we cannot imitate the sturdy oak of a century: then let it not be attempted; but there is generally timber in the place, or in the neighborhood, and the art of planting is so to dispose your own trees as to conceal the boundary where your estate ends and somebody else's begins. It is the very acme of good management to appropriate the surrounding trees to your own purpose; that is, make them features in your own landscape. Plant your own as if there were no fence or wall between you and them; and this, remember, is to be done by a judicious management of the planting at the fence and the clumps that are nearest. In some places barely top the fence by the shrubs—in others, get in the very tallest you can find; have a clump between the lowest and the walk, with shrubs con-

siderably taller than those at the fence. These features are calculated to break the appearance of a boundary, and by widening the boundary-planting considerably in some parts, you again destroy the monotony and give an appearance of extent. The shrubs used in planting should be chosen rather with regard to the wood around you. If, for instance, you are surrounded with firs and cedars, let some of your plants be the same; not the same sorts, but the same family. If the nearest trees are chestnut, or lime, or elm, or any other distinct character, do as much towards imitating it as the nature of your planting will allow. You are not to use all deciduous plants, because they do; but you may have enough of them, as near the boundary as may be. The most effective kind of planting away from the house is, to keep each clump distinct as to family—hollies in one or more; pines and cedars, laurel, bay—each and every interesting family may be provided with its place at the most distant clumps. Nearer the house, the *Magnolia* tribe, in all its hardy varieties, may form one or more of the conspicuous groups. The various American flowering shrubs may either form dwarf clumps in appropriate places, or foremost objects in the larger ones; and the border or belt plantation should be a mixture of everything lively and varied. The dark green of the holly and yew will contrast well with the brighter greens of the laurel, or the lighter hues of the *Aucuba japonica*, and other variegated shrubs. Regard, however, must be had to the rate at which the different trees grow, or you may have your front shrubs in a few seasons topping the back ones, and destroying the gracefulness of the groups formed here and there in the border, and spoiling the effect altogether.

The borders and clumps should be all made large enough to leave two feet for the summer additions of flowers, and to accommodate always, at particular distances, a few of the best flowering dwarf Americans, which show their blooms only in spring, and enliven the scene when it would

otherwise be sombre. The *Pyrus japonica*, with its scarlet flowers, begins in the autumn, and continues, if mild, all the winter. The dwarf almond is almost the first to show the approach of spring; and numerous other plants, unimportant in themselves, contribute to the beauty of a well-planted border. The path once laid down, the turves soon carpet the space, and nothing so soon puts a finish on the landscape garden.

We here speak only of the most simple style of gardening; we say nothing of water or rock-work, of hill or dale, nor of flower-gardens: all those require separate notice, and have had it; we merely recommend that, as a summer-house is the first thing everybody thinks of, it should be on a good large scale, in imitation of a temple; that the ground, if it be but an acre, should be laid out in landscape fashion, and that the rules of landscape gardening be observed in every movement:—a formal shrubbery is a frightful object.

#### THE FLOWER GARDEN.

Geometrical or Dutch gardens are very beautiful, when made in appropriate places and upon good principles, but the diversity of form is endless; and there is hardly a prettier feature in a garden establishment, if it be well managed. They ought to be formed with gravel walks and beds, and the designs should be very different from those flower-gardens which are formed by cutting particular figures in grass, though both should be done in such uniform figures as to make up a pretty whole. In marking the garden for gravel walks, the figure must be so managed as that the gravel walks shall be of equal width all through the figure, whereas in grass borders, which allow much more intermediate space, there is no need of confining the portion between the beds in any way. In fact, the portions to walk on may be of a particular figure as well as the beds themselves; but there should, nevertheless, be a complete uniformity throughout,

because, when the eye rests on anything manifestly artificial, it should always be in order and regularity.

It may, however, be said, that pieces of ground generally selected out of the general landscape—that is to say, in a recess of some kind, or nook of the garden—are not always of a uniform figure, and in such case the figure cannot be made uniform; but where such is the case, a square, or oblong, or circle, must be taken as large as the ground will admit, to contain the figure, and the remainder laid out independently, without spoiling the figure. For instance, say the plot of ground is neither round, square, nor any regular figure whatever; begin by making a positive geometrical figure, as large as it will allow, and let the other path be made first; all that is outside the path may be planted with shrubs, or made into a rosary, with dwarf plants nearest the path, and all behind gradually rising, or it may, if there be much of it, be put into grass. The inner portion, or figure, whether it be square, round, oblong, or triangle, is then to be laid out. We confess that, to us, there is nothing so effective as a circle; it admits of endless variety, and you may form a hundred designs, if you only play with a pair of compasses, as a boy does when he makes stars for his kite. Set your compasses with a double line, so that they form the path; get some paper ruled with lines to form squares of an eighth of an inch, and set the double point of your compasses to that width, and reckon this eighth of an inch either two feet or three feet, whichever you intend your paths to be; set your compasses so that you take in the exact size you intend the ground to be occupied: first draw your circle; but, as the outer path is to be any width you please, make proper allowance for it. Having made your circle, without altering your compasses, stick the point on the outer line, and make the double point commence at one side, and draw it over to the outer edge on the other side; put the point in again on the outer line, where the other left off, and continue to do this until you

have perfected the figure as far as it can be perfected, by putting the point of the compasses into the marks where the other or moving points come home. If the point is now put exactly half way, and another series of circles or portions similar to those already made are worked out, the divisions will be more numerous, and the shapes may be more diversified. But, in order to get a greater variety of forms, and to get some practice, it is better, perhaps, to use the single points only, and, without altering the compasses at all, make a circle; then, with the point on the line, draw a second; place the point on the line of the first circle where the second crosses it, and make a third; the point where this crosses make a fourth, and keep on until six circles round the first complete a figure. By commencing another series, with the point half way between the points used for the six, you make twelve. The whole circles being filled with squares already ruled, you will be able to mark out beds of the most extraordinary shapes, but perfectly uniform. These may be still more diversified, by drawing from the centre point one circle half way between the line of the first circle and the centre point, by altering the compasses to half the width.

A man inclined to form plans for flower gardens will derive infinite amusement from the numerous forms that can be made with geometrical precision by merely playing with a pair compasses. When we come to reduce this to actual practice, the compasses must have a double point for the paths, for these must be of one uniform breadth all through the bed, and in no case should the width come double. Those, however, who have not the double point, may produce the necessary lines by opening the compasses as much as the path is to occupy.

It would be scarcely worth while to give examples, because the instant any working man begins with the compasses, he will see there is no difficulty in producing endless variety.



The plans of beds to be cut on grass merely require that the portions to be planted should be wider apart; grass must not be too narrow; the grass must form the carpet, and the beds the pattern: taste, with the aid of ruled paper and the compasses, will suggest a thousand modes to please the eye.

But when the garden is made, there is much to be considered in the planting. Not one flower garden in a hundred is ever decently filled; uniformity and symmetry are lost sight of in the endeavor to use as many kinds of flowers as possible; and not one have we seen that has not been spoiled by the mode of planting. Generally speaking, it is desirable to have twenty-four beds—three, or six, or twelve, of one form, besides a centre one—though to see one of these geometrical gardens in perfection, the centre should be gravel, that the proper effect may be seen from the middle, whereas a centre bed deprives us of this view. If, as is usual, there be six beds of a form, it is throwing all the advantage away to aim at too many colors. Every alternate bed may be of one subject, which, being uniform, gives a good effect; but we prefer all six alike. Another six may be all alike, and of another color. So also may be a third and a fourth six. Annuals are great favorites in geometrical gardens, but there is nothing comes up to the verbena for length and steadiness of bloom, unless it is the scarlet geranium. Let the outside of the figure be planted with anything you please, but have the figure itself planted with subjects that require no changing. The more intricate the figure, the more the necessity for dwarf plants and for permanent subjects. Those beds which form the outside circles cannot be better planted than with various scarlet geraniums; they are striking and lasting. The diversity of colors in the verbena, and the exceedingly dwarf habit of the creeping varieties, afford great facilities for completing the inner beds—there are purple, white, pink, lilac, salmon color, crimson, and indeed almost every shade but yellow may be secured from *Mav*

until the frost cuts them off. The only color we seem to want is yellow, and these are, for the most part, temporary.

If, however, changes are to be made, we have abundance of colors among the annuals and perennials of other kinds, so that we need not cross our fancy for colors. The nemophilas, convolvulus, and *Lupinus nanus*, give us blue; the eschscholtzia and *erysimums*, orange; the *minulus* and yellow pansies are bright and beautiful; but to see a geometrical garden stuffed with heliotropes, which are nothing to look at, or mignonette, or any of the usual straggling and ineffective subjects, is aggravating to every man of taste.

Everything in one of these flower gardens should be striking and dwarf; they must never overrun the box edging, because the figure is at once destroyed. There is a vast difference between the management of these and mere clumps on lawns or beds in any other place. It is of the highest consequence to keep everything within the figure, wherever that figure is valued.

The formation of these gardens on paper, in the manner we have hinted, renders it very easy on the ground, because it will occur to any practical man that by placing a stake on the spot where the point of the compasses is placed on the paper, a cord doubled and tied the exact length you want will be your compasses; put one end of the loop over the stake, and put a stick to the other end, and you may mark your circle as well on the ground as your compasses do on the paper. You therefore dig and trench the whole plot, level it and roll it to an even surface, then mark it by means of your line and stakes until you have your figure on the ground; when you have all your marks made, rub out with the foot all those you do not intend to use; leave none but your beds and the paths between them to divide your attention. You then commence operations by throwing out the earth a spit deep along the middle of your paths to make room for chopping the sides down like a bank, carefully pressing the back of the spade in a sloping direction, so as

to make the beds all perfect and standing in relief; the earth you have thrown out of the paths is as well on the beds as any where. This being all perfected, and the loose earth chopped from the sides being in the path, trim all your box of a length, with the tops cut square, and thin it out almost into single stems; the box when planted ought not to be more than an inch wide in any part, and, unless it be torn into small plants, you cannot manage to make it even. The surface of the ground being perfectly level when you begin, and the earth thrown on to the beds lying on the middle, and not interrupting the line of plan, take your box in sufficient quantity, and lay it against the bank you have formed, with the tops just half an inch above the surface, and this being cut square, can be so well adjusted that when finished it will be as level and even in thickness as it can be made. As you lay it, bring the loose earth in the path up against it to hold it in its place, forming a bank outside to keep it firm. We need hardly say that, if this be all properly done, the figures will be perfect, and the box all alike the whole length. You have then only to wheel the gravel in, and, with a narrow roller, press it into its place without disturbing the box, the figure of which, if kept properly preserved, will last unimpaired many years.

The principal points to attend to are—first, to roll all the ground smooth, and see that it is level; next, so mark your figure as that you can see well what you are about, putting out those marks which are mere surplusage—that is not wanted; all the marks that cross the walks and confuse the figure, but which, nevertheless, like the crosses and marks on the paper, come on the development of the figure—so as to leave the figure perfect and easy to decipher. Then clear out a good spit deep all the centres of the paths, and throw the stuff on the centre of the beds if they are large; but if they are numerous and small, it may be necessary to get rid of it by wheeling it away altogether; generally, however,

the beds are large enough to take it, and only rise a little for it in the middle.

We have said nothing here about draining, because we presume upon that having been performed on every part of the garden before you commence. The chopping out of the figure is rendered very simple and easy, by removing the earth from the middle of the paths; but there is some ingenuity in pressing the soil of the sloping bank you form, so as to make it firm. Gardeners who are used to the work, press the back of the spade against the part they leave, at the same time that they take the other away; on the correctness with which you attend to the lines of the figure depends the entire beauty of the flower garden up to the planting, which, if ill-managed, will destroy the best figure in the world, or at least mar the effect.

It is necessary, first, to choose dwarf subjects that bloom as close to the ground as possible; secondly, to put the colors in uniform—that is, if six equal beds are round a centre, only to attempt two colors or two mixtures, one each for the alternate beds; then three scarlets at triangles, and three purples, yellows, whites, or blues at the points of the other triangle. Some would think they met all the necessary uniformity by three different colors, one opposite the other, but the magic of a well-balanced geometrical figure is destroyed at once, as will be seen in an instant by trying it on paper. Thirdly, for the sake of saving trouble, use such subjects as will not require changing; for though we admit there is a charm in change, it is very difficult to manage it without losing bloom for a considerable time, or occupying many hundreds if not thousands of pots to bring on things that may be got to bloom for such changes.

It is possible to manage thus for a succession of bloom, with abundance of trouble and means. See how many pots will fill all the beds at six inches apart, and that the earliest advantage may be taken of the opening spring, let so many pots be used for spring bulbs, three colors of crocuses, yel-

low, blue, and white; the same of hyacinths, confining the latter to the dwarf kinds; then there are snow-drops, *Scilla sibirica*, and the dwarf daffodil; these latter are even before the crocuses. The pots of everything should be one size, what is called large sixty, or four inches at top but much smaller at bottom. To follow these, which will last from February till May, the verbenas in every variety may be brought forward; but there is a choice of fifty things that may be in bloom in May. The beauty of this pot system is, that all the pots being of one size, they have merely to be lifted out when done blooming, and those in flower dropped into the same holes. An hour, with proper assistance, would do thousands of pots, and the whole face would be changed before breakfast any morning, and the old pots wheeled away. Generally speaking, flower gardens are not made up till May, and then there is abundant choice.

In very small places, always in sight, the pot supply is good, and it is carried out with great advantage in villa gardens, where everybody who passes can see the place.

There is but little taste exhibited in bedding out plants generally. Those subjects which belong only to the backs of wide borders are frequently thrust into pretty small clumps, the form of which is destroyed before the plants are half grown. Tall fuchsias, salvias, and other similar tall plants, are totally unfit for any given figure; they are only fit to be placed in the background. If they are to grace a clump, it should be on a large scale, and without any particular outline or figure.

The prettiest way of showing off anything ennobling or tall, is in clumps with basket or rustic borders, that they may appear like baskets set on the lawn. Roses look better so than any other way, and if the basket border be well adapted, there is hardly a prettier device. Heliotropes, mignonette, violets, and aromatic plants generally, which are really wanted for their perfume, and are nothing to look at, should be always placed in the nooks and corners. They

form no feature in flower-beds, and the perfume is quite as pleasant when they are not seen as when they are.

There may, however, be great liberties taken with isolated beds cut on lawns; it is only when they form part of a figure, that we are bound under any circumstances to preserve that figure, and more particularly if it be at all dependent on angles or intricate windings. Many consider the figures cut in grass to be superior in effect to those formed with gravel paths and box; we do not. Grass is such a finish in itself, when well kept, that we would not consent for a moment to impair the expanse of the centre by cutting up any part of it for flowers. If there needs must be flowers on grass, let the beds be at the side parallel with the main path; let there be a verge of green a foot wide—the bed cut close up to that—and whatever diversity of figure may be required, let it be inside. Vary the figure as much as you please inwardly, so that it reach a mere verge of grass next the path; but to cut a lawn into holes, beds, clumps, or whatever else you may call them, is to destroy the beautiful expanse which is the very charm of a lawn. Nevertheless, it is the whim and fancy of some to cut even geometrical figures in grass; and although we have an insuperable objection, there are some points to attend to where it must be done, to make it even tolerable. For instance, as the flower beds are useless unless they are attractive, visitors always frequent their vicinity; and if there be not ample room, the grass is soon destroyed by merely walking over the same spot repeatedly. On this account the beds must always be smaller in proportion than they are on gravel, where a path may be trampled on from morning till night, any day in the year, without damage; but if the grass be ever so expansive in proportion to the beds, it is soon damaged if there be many visitors. This is our grand objection; for when grass is worn a little, it cannot be brought up again without prohibiting a footstep altogether, or laying down fresh turf; and either of these

done at the very season a place is most frequented, is a serious objection.

It is not uncommon to see figures cut in the grass on both sides of a long, straight walk. Whoever adopts a straight walk as a feature, finds something is required to take off the monotony and divert the eye, and this leads to something perfectly obnoxious to good taste. There is nothing elevated in the detail, because there is a common mechanical notion in the path itself. There may be mathematical precision, but there is no grace in a straight road; and the form of clumps or flower-beds on the sides of the straight road is necessarily mechanical also, and subject to everybody's objection; for if once we descend to mere frivolity, and make uniform half-moons, or horseshoes, or diamonds, or circles on each side of a straight path, we might just have at once a row of posts, and chains hung on festoons for the children to swing upon. If a piece of lawn is to be devoted to a flower-garden, and the geometrical figure is to be adopted, let it be so made that the eye may look down upon it from an eminence. Rosherville Gardens afforded this opportunity. There is nothing in the figure but what the compasses and a ruler would accomplish; and what will they not?—but when the fancy beds were nearly filled and in bloom, we could look down from the chalky heights and fancy the lawn a green carpet and the beds a gaudy pattern, standing up in bold relief; but, as we have already said, the grass must form the principal quantity, and contain a space large enough to prevent wearing in any one track.

The figures necessary for grass are as easily contrived as those intended for gravel walks. The identical figure, with its thousand circles, and crosses, and angles, that will give us fifty varieties of form for a Dutch garden with gravel walks, will give equally as many for a grass carpet. To look at one of these practice papers, as we may call them, is like pleasing one's fancy in a coal fire. We may fancy a

thousand forms by looking in one, two, or more of the minute divisions, in what shape you please, and these are sure comparisons. There is not a division nor half a dozen joined to make a form, but five more can be found to match it. We feel more than half inclined to give an instance of a paper scratched all over with circles of different sizes on a ground-work of squares; it would give an idea of the diversity to be worked out; but it is so simple an operation to provide, that it would almost imply deficiency of intellect to publish one, and we would rather have the young gardener try.

But it may be said that everybody does not like a figure formed within a given square or circle; that the ground may be more favorable for an oblong. It is granted: then work your figure with two circles, and it will be twice as long as it is wide, or a circle and a half, which will make an oblong not so divided; but you must mark out the ground you intend to lay out, and always keep your eye upon uniformity. Draw circles without number from various points, only keep up uniformity; that is, if you place the point of your compasses on a spot nearer one side or end than the other, do the same on the other side or end, that there may be corresponding circles. The ruled paper, be it remembered, already gives you the advantage of paths crossing in various directions, and saves many speculative rulings during the process of designing.

In the transfer of any design from the paper to the ground, you have only to remember that the stake placed firm on any part of the bed or figure forms the equivalent to one point of your compass, and the loop of any dimensions you please put over it, and the point you mark with the other end of the loop, is the working point of your compass; the shortening or lengthening of the loop opens or closes your compass, while the squares on your paper enable you to do everything by scale; the eighth of an inch may be the rep-



representative of one foot, two feet, or three feet; you cannot go wrong.

With these remarks, and a few evening's practice with the rule and compasses, you will produce an endless variety of plans, all tending to illustrate the beauties of geometrical gardening. But they must be made in places which do not interfere with the general features of the establishment. If there be no natural recess or nook calculated for the place, you must take the most eligible, and plant it out as if it did not belong to the concern. It is not generally desirable to make a place smaller; but better anything than introduce formality in a landscape. It is not difficult to shut out a space. It is true that the first year, and before the shrubs have a little growth upon them, the design will be seen through; but as soon as the planting fills up a little, the object is concealed. The most desirable place perhaps is a corner, and that because the concealment is not so conspicuous. By bringing out a belt of shrubs far enough to enclose the necessary space, you may either conceal the entrance by planting one belt to overlap the other, or by erecting a small temple or covered seat as an object in the landscape. The flower garden may be placed at the back. Flower gardens, straight walks, terraces, statues, and all manner of architectural contrivances, may be made in front or at the back of greenhouses, conservatories, or other ornamental buildings, and beds laid out in appropriate style. The plan of the buildings will suggest the most eligible plan for the garden, but whatever is formal should be planted out from the general landscape, even when the formality is forced upon us.

#### THE GREENHOUSE.

The greenhouse is always after a pit or frame, the first glass structure that anybody erects, and the only one that a builder who wants a tenant in the country, thinks of building to go with his house. Wherever there is a glass

house of any kind, it is called a greenhouse; it is one remove from the garden frame, or pit, and when there is no other horticultural building, it is invariably used for a mixture of plants of all families. But there are certain appropriate plants which will so far accommodate each other as to wants and sufferings, that where one will live another will be doing well, and by a little care a goodly show of plants may be maintained.

The ordinary form, and the best, for a greenhouse of this kind, is a "lean-to," as it is called; that is, a wall of the proper height forms the back; the front is two feet six of brick-work, or thereabouts, and two feet of glass; a table or shelf two feet wide, or, if the house be roomy, perhaps two feet six inches, next the window, and a stage sloping like the roof, the front shelf the same height as the front table, and rising shelf above shelf to the top. The width of the house from front to back is generally according to the room; it should not be less than twelve feet, but a roof made of two eight-foot lights, and at an angle of forty-five degrees, would be advisable. The heating required in common of a greenhouse, is only enough to keep out frost, and a degree or two of frost out of doors will hardly penetrate in a night, so that many people prefer the common flue to hot-water pipes, as the heating is more permanent except in a hard and continued frost.

The greenhouse, in places where there is no other glass building, requires a careful selection of plants, first to keep up a diversity, and second to mind that there be none but will agree with each other in treatment, and do well with the like attention. Camellias are the most important, because they are noble plants in or out of bloom, and in themselves afford considerable variety; the red, white, blush, pink, and striped, form pretty contrasts, and this family is by no means tender, or difficult of management. Azalea indica, quite as hardy, follows with its gorgeous flowers before the camellia has left us, and of this we have scarlet,

crimson, pink, light-rose, purple, white, and striped. *Horreas* gives us a rich deep-blue pea-flower early in the spring, and are as hardy as either of the above. *Cytisus racemosus* yields a rich perfume, and is a perfect mass of golden-colored flowers. It is impossible to overlook geraniums, which are such general favorites; and while we attend to some of the showy novelties, we must not forget to provide half-a-dozen of the dwarf scarlets to stand here and there in the house, for they give a brilliance which hardly anything else will to the miscellaneous collection. *Cinerarias*, from their gaiety and early blooming habit, ought not to be omitted; and for the winter, Chinese primroses afford some variety and are very beautiful. So also some heaths may be selected for the sake of their bloom in the winter months, and because they will stand among the other plants we have mentioned. The acacias are an interesting tribe, nearly all yellow or straw-colored flowers, but for the most part very abundant blooms, and as hardy as anything we have mentioned. *Chorozema varium* and others make a variety of foliage as well as flowers, and are adapted for greenhouse culture. There are many other plants that would take people's fancy, but a house well filled with these would be highly gratifying, whether there were a few of the best kinds, or a more general collection of each.

The greenhouse may be built cheaper than any other; the glass need not be more than six inches by four all over the house; it wants no puttied laps, no particularly expensive wood-work, and the brick-work quite plain; the top-lights may slide down, the front-lights swing with hinges from the top, and opening outwards, to be propped out by common fastenings, or they may be made to slide—in which case, however, the front can but be half opened at any time, because one window or sash must be placed behind another. In the former plan the whole range can be propped out, and if it were at all desirable, they could be made to push out square with the top, to admit the whole space of air. The

front table or shelf should be generally used for small, choice plants that require most attention, because they can be easily got at, and best seen; the stage behind will hold all the larger ones, the more gaudy being the most distant; a camellia, for instance, could be seen from the most remote corner.

The greenhouse, however, besides holding all such plants as we have mentioned, would forward hyacinths considerably, and produce the flowers of all bulbs a month or six weeks earlier than the open ground, and perhaps nothing would contribute more to the beauty of a greenhouse cultivation than a few well-chosen hyacinths, narcissuses, &c., to intersperse among the other plants. The greenhouse, in large establishments, is employed to assist in supplying the conservatory, so that as soon as camellias, or azaleas, or any other plants, are found enough in bloom to be interesting they are removed to the conservatory, and their places filled by such plants as may be brought forwarder by their removal from the open ground. Roses, for instance, are forwarded by removal to the greenhouse, and if they are intended for forcing in a warmer temperature, they should always be commenced by a change from no protection at all to that afforded by the greenhouse; and when inured to this, they may be placed in the forcing house, kept at first down to a low temperature, and gradually increased; but roses bloom well in a greenhouse without any other aid than the mere absence of frost and chilling winds.

The great object in all greenhouses is to keep out frost without getting up the temperature too high; the one is necessary, but all that the house is heated above forty-five by day or forty by night during winter, draws up the plants and renders them weakly. The geranium house, where these plants are grown upon the system of propping up every shoot, will not do with the common treatment of a greenhouse, for it has to perform the part of a forcing-house as well; the house is frequently syringed all over, and shut up

with the plants at a temperature of fifty-five to sixty degrees; then, being in this excited state subject to the green-fly, the plants require to be frequently fumigated—an operation which, since the invention of Brown's patent fumigator, is not half the trouble, nor a quarter of the expense incurred by the use of the fumigating bellows, or any of the other means usually resorted to. Thus, therefore, although the geranium does admirably in a common greenhouse, and without any other treatment than will do for camellias, and heaths, and Botany Bay plants generally, it is the fashion to force them for May and June exhibitions, to draw them up weakly, and tie them up to scores of sticks to hold them in their places; but if we desire to see geraniums in perfection, we must go where they are grown without heat, and with plenty of room, light, and air; where they support themselves instead of requiring props, and where the color and texture of the flowers are as superior as the growth of the plants. Treat the geranium like the camellia and the heath, the tepacris and the azalea, and you will have color, health, size, and fine foliage; force it, and you impair all; but as forced plants have only to be compared with forced plants, the distinction is not seen; in short, the greenhouse, the single house for the assemblage of all moderately hardy things, or rather moderately tender things, is the most interesting of the horticultural buildings; it is the cottage conservatory, the pet house of lady gardeners. It stands always open in mild weather; there is always something inviting in it, and it can be always made to supply a few violets, a bit of mignonette, or a camellia bloom, any time in winter.

#### THE CONSERVATORY.

This may be called the show-room of the garden, and should be attached to the house, because it will be visited in all weathers; generally speaking, it adjoins and opens out of a principal room; and as it should be a kind of winter gar-

den, it should be large enough to walk in. Of the form and plan which depend on a diversity of tastes among builders and owners, we must say but little, nor describe at great length. There are some essential points to attend to, and so that these are noticed, we may leave the external style to the artist and his employer.

First, the larger it is, the more convenient and effective; on this account we begrudge every pound laid out in ornament at the expense of size. It would cost as much to build a trumpery thing of ten feet square after some fashions, as it would to erect a plain house of fifteen by thirty; and this is the smallest we should care to possess, for it merely allows of an eighteen-inch border all round a three-foot path, and a slab, or, if preferred, a bed of six feet in the middle; and this is as little as can be made subservient to an effective display.

The conservatory borders may be kept furnished with potted plants, whether bulbs, annuals, or perennial shrubs; and as they decline in beauty, they can be lifted, and others, in the same sized pots, dropped into the same holes. The centre, if there be on the establishment store greenhouses, pits, and other nurseries for plants, should be a slab or table, because the plants will be the better for changing, while by this means the conservatory may always be kept filled with flowers. The temperature of the conservatory, in which stove as well as greenhouse plants are arranged, and where forced flowers, which are more tender than either in their actual bloom, contribute to the show, should not be under fifty degrees, because a lower temperature would damage the forced flowers and stove plants, and that atmosphere is not too warm for greenhouse plants; but the greatest care should be taken to keep it down as nearly to that as possible, otherwise the hard-wooded greenhouse plants would suffer, and the bloom of many others would be shortened. In setting out the centre table, the taller plants should be in the centre, and the shorter ones on each side, the shortest of all

being on the outside, so that the plants would form a fine bank sloping on both sides. The table should be a foot narrower than the space left for a bed, for the double purpose of giving room to walk and having room for a row of potted plants at the foot of the table all round. The stove and forced plants to be from time to time brought into the conservatory, should be removed, a day or two before, to the coolest part of the forcing house, or stove, to make the change less sudden; because if, as the stove generally is, a plant is in a temperature of sixty-five, the sudden removal to fifty will hurt the flowers that are out; and if the forcing house is above sixty, the same precaution is necessary, as a hardy plant, forced into flower by high temperature, would, by a sudden change of fifteen degrees, be drooping directly. Another precaution necessary is, to remove them as they come into flower, and not wait until the blooms are opened; a bud, even forward, will not feel a change that would actually destroy a perfect blossom.

We need hardly say that it is quite possible to keep a conservatory well supplied with flowering plants the entire year round. Camellias may be commanded from November to April; rhododendrons, and both Indian and American azaleas, January till July; kalmias and other Americans can be made to help out a great part of this time also. Many stove and orchideous plants can be had all winter; bulbs, from Christmas onwards; Chinese primroses all winter. In the spring, the greenhouse will furnish cinerarias, heaths, epacrises, hoveas, all the hard-wooded plants, geraniums, &c., which literally form a blaze of bloom. The stove yields a full share of flower; but the difficulty, if there be any difficulty in keeping up the show, is, when the out-of-door beauties predominate; but pot-culture of out-door subjects must make up for any deficiency of exotics. The passifloras of the stove will see us through June and July. The hoveas contribute to the good effect. Balsams come at an excellent time, to brighten the scene; and many autumnal roses,

grown out of doors, but in pots, may be removed to the conservatory, to aid and assist. Annuals of the better kind in pots, are of great use, as are late-flowering geraniums, and dahlias in pots. Many climbing plants, and, almost every month in the year, some orchids, enable us to keep up a good show in the conservatory. There is rarely a month in the year without several heaths in flower, and these always last a good while. In short, what with retarding some things and forcing others, flowers may always be had in moderate quantity and variety.

To maintain a proper heat in the conservatory, some consideration must be given as to the means. The height and size must always be considered. The most complete way, as regards neatness, is, to put the heating apparatus under the path; but, as it is not always the most economical, there must be pipe enough to command the necessary temperature with boiling water, as this requires less attention than any other mode of heating, and is in general more steady. If the pipes are above ground, they are unsightly, but they are more effective; and where a six-inch pipe and return would be wanted under the path, a four-inch pipe and return would do, and more than do, above. The nearer the pipe runs to the walls, at the lowest part of the roof, the better; because, as the heated air ascends, it then takes the whole slope of the roof, and falls in the centre as it cools; and it is a good plan to have the table formed with a sort of open-work, or wooden shelves, of half-board width, with half-inch vacancies between them, because it gives less obstruction to the circulation of air which is always going on when one part of a house is heated.

The glass of the sides should be within twelve or eighteen inches of the ground, that all parts of the building may be perfectly light; and if we determine to have the pipes above ground, they must be close to the twelve or eighteen inches of brick-work which forms the base under the glass. The two four-inch pipes, one above another, will just occupy the



space of the brick-work; and if it be desirable to have them, let there be a back made to the border as high as the pipes, and an open iron shelf upon it, so that a chamber will be formed, and the circulation of air will be increased, if from the bottom of the chamber there be openings here and there conveyed under the border to gratings in the path. We have in all cases preferred the conical boiler, and we do in this; but as there is frequently a difficulty in finding a place for the firing without being an eyesore to the conservatory, it may be necessary to carry the pipes some distance underground. In this case, make a trough underground to hold the pipes, and fill it up all round the pipes with bruised or pounded pumice-stone, (a complete non-conductor of heat,) in which the pipes will lose no heat—at least, suffer no perceptible loss of heat, in twenty or thirty yards of underground transit. Of late, conservatories have been constructed upon such plans as reduce them to mere covered gardens, without any means of heating, but with all the necessary neatness and closeness required to shut out the external air. Such conservatories would be formed, perhaps, in much the same way as others are for heating; but they are supplied with none but hardy and half-hardy plants. With great care and attention to the shutting-up in time, and not opening till the temperature of the external atmosphere has been raised a little, these conservatories are kept well furnished with camellias, hoveas, azaleas, many kinds of heaths, and others that may be called hardy green-house plants. Numerous climbing plants will even stand all winter; but, with the same management that we have already described, a good deal may be done with plants just got ready to flower, and brought into the conservatory to bloom. The study, however, of a conservatory without heat, is peculiar. There is abundance of very hardy and very early things—bulbs in particular—which only require absence of actual frost to bring them exceedingly early; and such as these will give us flowers at Christmas, after a mild autumn. There is no

difficulty, then, in relying more on these than on any kind of forcing for spring flowers. The great object is to watch the gardens for a year, and make notes of all the autumn and very early spring-blooming flowers. By planting these in the borders, or growing them separately in pots, we may command them a little earlier, or a little later. Violets may be had all the winter. Noisette Fellenberg and the common China rose may be kept in bloom in pits and houses; and therefore a succession may be kept up in pots, to change such as go out of bloom. The *Magnolia purpurea* and *conspicua* may be planted out. Rhododendrons and azaleas of the American kinds, and some fine hybrids, will stand a moderate degree of frost, and therefore become very useful. As a climber, *Clematis azurea grandiflora* is the most showy and beautiful of the whole family, and would grow out of doors, to say nothing of under glass. Those, therefore, who object to a fire near the house, or who have no convenience for it, may have their winter-garden under glass, and always have something growing and blooming while frost and snow forbids a walk in the open grounds.

The most economical form for a conservatory is a ridged roof. The side upright from the ground to the lowest part of the roof should be not less than eight feet, and ten would look more noble. The roof should rise seven feet six inches, the lights should be five feet nine inches wide, with a tie from plate to plate at every rafter, the nearer the better; and of iron, that it may be light. Climbing plants should be directed to these, so as to form a pleasing feature when covered; and there is great choice for the purpose among the passifloras, clematises, and other robust and showy families. The toplights should let down, the side-lights, or upright glass sides, as they may be called, should all open; and as the more convenient and elegant, as well as useful plan, they should be sashes like dwelling-house windows, the lower ones to push up, and the upper ones to pull down. The glazing of the sides may be of large glass panes; but for the roof,

six-inch width is enough, and the length may be anything; but, for economy, six by four is large enough, and by far the cheapest. If the conservatory be planned thus, without any extra ornament, due regard being had to neatness, good workmanship, and clear glass, you may build such of a much greater extent for the same money, than you could any of the more fanciful kinds, which cannot but get out of fashion as taste changes; but, as this form is the best for use, the best for plants, the most convenient, and the most economical, it will never get out of fashion. The interior will be all that can be wanted. The outside will be the form of a thousand others—the least likely to take from, or spoil the beauty of the house—the best adapted to show off the plants, and the easiest managed.

The luxury, for such it is, of a winter garden under glass, may be imagined better than described, when we speak of one under our own management. The wind was east; the front park of the mansion covered with snow, which was drifting in our face and almost blinding us and the horse we were driving; the thermometer down at 22°. Nothing could be more dreary. A few steps across the hall of the mansion to the drawing-room on the ground floor brought us to another climate. The large glass doors of the conservatory were thrown open; there was a good fire in the room, but the conservatory ranged 50°, and the centre table had a superb bank of flowers, as gaudy as can be imagined—splended camellias, rhododendrons, *Hovea Celsi*, *Azalea indica alba*, *Epacris grandiflora*, three or four heath, some fine orchideæ, especially *Oncidium papilio*, numerous bulbs, violets, mignonette, a few China and forced roses, formed a mass of beauty so utterly out of season, and contrary to the season out of doors, that notwithstanding we had seen the contrast over and over again, it was so striking after a month's absence that we hardly know whether we felt till then the real charm of a conservatory

The following objections are urged against leaving green-houses open into the house :

Every day the many gallons of water given to the plants evaporates and rises into vapor to settle on the various objects within reach. Therefore, in the drawing-room, or the room adjoining the conservatory, there should be nothing that will take injury from damp, because it will settle in pure water on the walls, and sink into tapestry curtains, the backs of paintings, the covers of sofas and chairs; in short, it will lie or hang in drops on whatever will not absorb it, and sink into all that will. Besides, therefore, having nothing that will take injury in the room adjoining, there should be great care taken to keep the conservatory doors shut, except when really required open; and when open, to keep all the communications that go from the room to the house closed. The conservatory should always be kept as open as the weather will permit, to give air to the plants and let off the wet, which may be seen, when the house is closed, running down the windows and walls in copious streams. There is no good without its evil, no enjoyment without some corresponding trouble to maintain it. The conservatory, so great an ornament, so exquisite & luxury, may, without care, be the means of producing sickness in the house, destroying the furniture and ornaments, and doing endless mischief, unless it be counteracted by attention. Let the throwing open of the doors be the exception and not the rule. Keep the damp air from the house as you would a pestilence. It is delightful to smell the perfume, but it carries poison with it if allowed to make its way all over the house.

The same argument tells against keeping too many plants confined in dwelling houses; remember that if you pour a few quarts of water once a day into the pots in which they grow, it will be all gone in a short time in vapor, and settled by condensation in your curtains, looking-glasses, pictures, the paper on the walls, and into your own lungs

If you must have plants, let the windows be open in summer, and moderate the number in winter. It is not that plants are unwholesome, or the perfume injurious; it is simply the dampness which arises from the soil, and which you charge ready to go off again every time you put water to them. If the same quantity of water were sprinkled all over the floor of a bed-room, as is frequently given to the plants in the same room, the occupant would fancy the damp would almost kill her; but gallons are distributed among the plants, which give it off again in vapor as surely, if not so quickly, as the floor would. Where, therefore, you keep plants, let them have all the air the whole day; and, that you may suffer as little as possible from dampness water them the first thing in the morning and open the windows. In winter this can only be done on fine days; but, fortunately, in winter, plants want but little moisture, because it evaporates so slowly as to be of no consequence.

## CHAPTER XIX.

## COST.

THE cost of building is varied by the kind of material of which it is built, the time when it is erected, the style and character of the workmanship, and the locality in which the work is done.

If the building be of stone, in some neighborhoods it would be cheaper than wood, while in others it would be dearer. So is it with wood: some kinds are cheap in one place and dear in another. Here is the difficulty of attempting to give, with any precision, in a book of this character, estimates which can be relied upon. Practical architects, of any extended experience, have found that builders do not agree in their estimates, even when made from the same drawings and specifications, and to be erected on the same spot; it is often the case that they vary thirty per cent. Another variation in cost, is made in the quality of the workmanship. All the conditions of the architect's specification may be fulfilled by the builder, and the workmanship be thirty per cent. inferior to the work done by another builder.

In our statements as to the cost of the cottage built after the designs which we have presented, it should be borne in mind that the amount stated is the *average* cost.

The TERRA DEL FUEGAN COTTAGE costs no money, and but little time, attention, or labor.

The PRAIRIE COTTAGE can scarcely be priced; it is never built where money circulates, and of course we cannot name its cost in money. The expenditure of labor is light, while the beauty of the design consists in adapting the soil on the spot to the purpose of building the walls.

The VILLAGE COTTAGE would cost about nine hundred dollars; the ITALIAN COTTAGE about seven hundred and fifty dollars; the THATCHED COTTAGE about seven hundred dollars; the COTTAGE OF THE SOCIETY FOR IMPROVING THE CONDITION OF THE POOR, nine hundred dollars.

The cost of PRINCE ALBERT'S MODEL COTTAGE is not stated; it would be of but little service if it were, for we do not believe that it will ever be adopted or copied in this country.

The RURAL COTTAGE is built of brick, with the walls arranged hollow, and costs six thousand dollars; but if built of wood, with the walls in the ordinary manner, it would cost about four thousand two hundred and fifty dollars. Beautiful houses might be made, of the same size after this same design, at a cost varying from three thousand five hundred dollars to five thousand dollars.

MR. FOWLER'S OCTAGONAL COTTAGE cost him about ten thousand dollars.

RURAL HOME No. 1 would cost about thirteen hundred dollars; RURAL HOME No. 2 about two thousand dollars. RURAL HOME No. 3 about one thousand five hundred dollars.

The SUBURBAN RESIDENCE which is shown in the frontispiece, cost fifteen thousand dollars.

The OCTAGONAL SUBURBAN RESIDENCE, designed by WILLCOX, he estimates would cost fifteen hundred dollars.

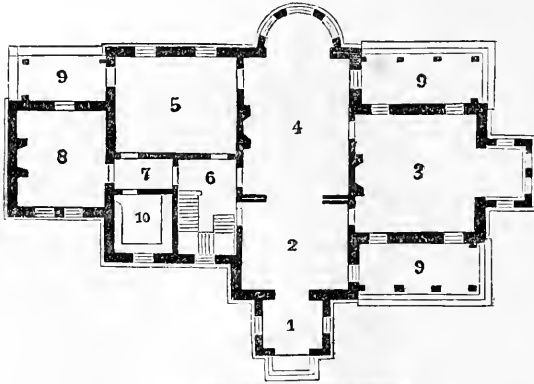
The BYZANTINE COTTAGE is estimated to cost two thousand five hundred dollars.

The GOTHIC SUBURBAN RESIDENCE, designed by MR. DAVIS, was estimated to cost about fourteen thousand dollars; but we believe the actual cost of the building proper was eighteen thousand dollars, while the expense of the out-buildings, ornaments, and decorations, cannot be less than three to five times that amount.

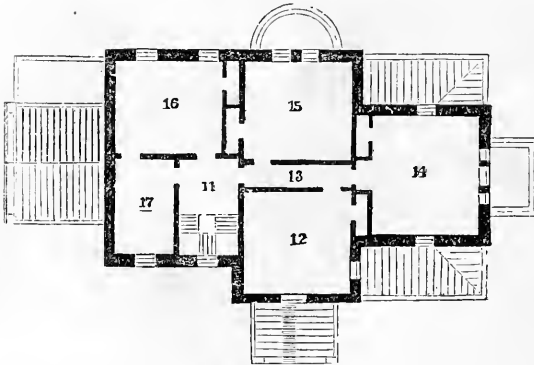
## CHAPTER XX.

### TWO RESIDENCES.

THE Byzantine Cottage does not ordinarily suit the general observer. The reason is, because it is Byzantine, and is in this country usually found out of place.



GROUND PLAN.

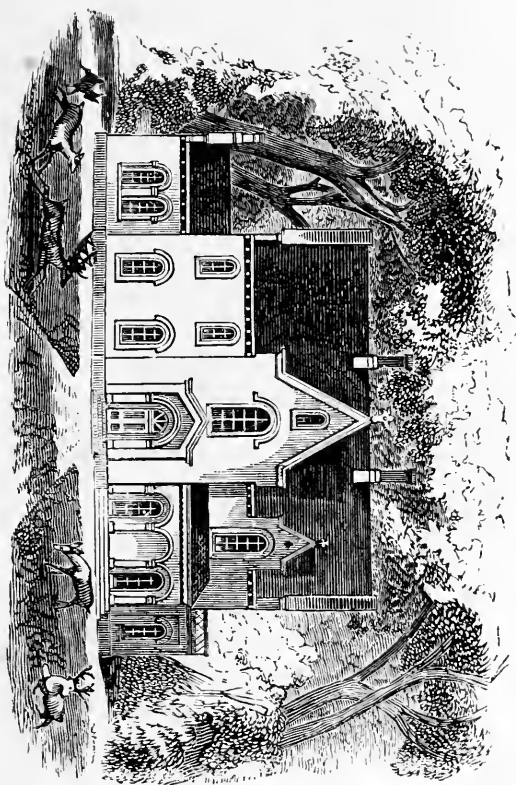


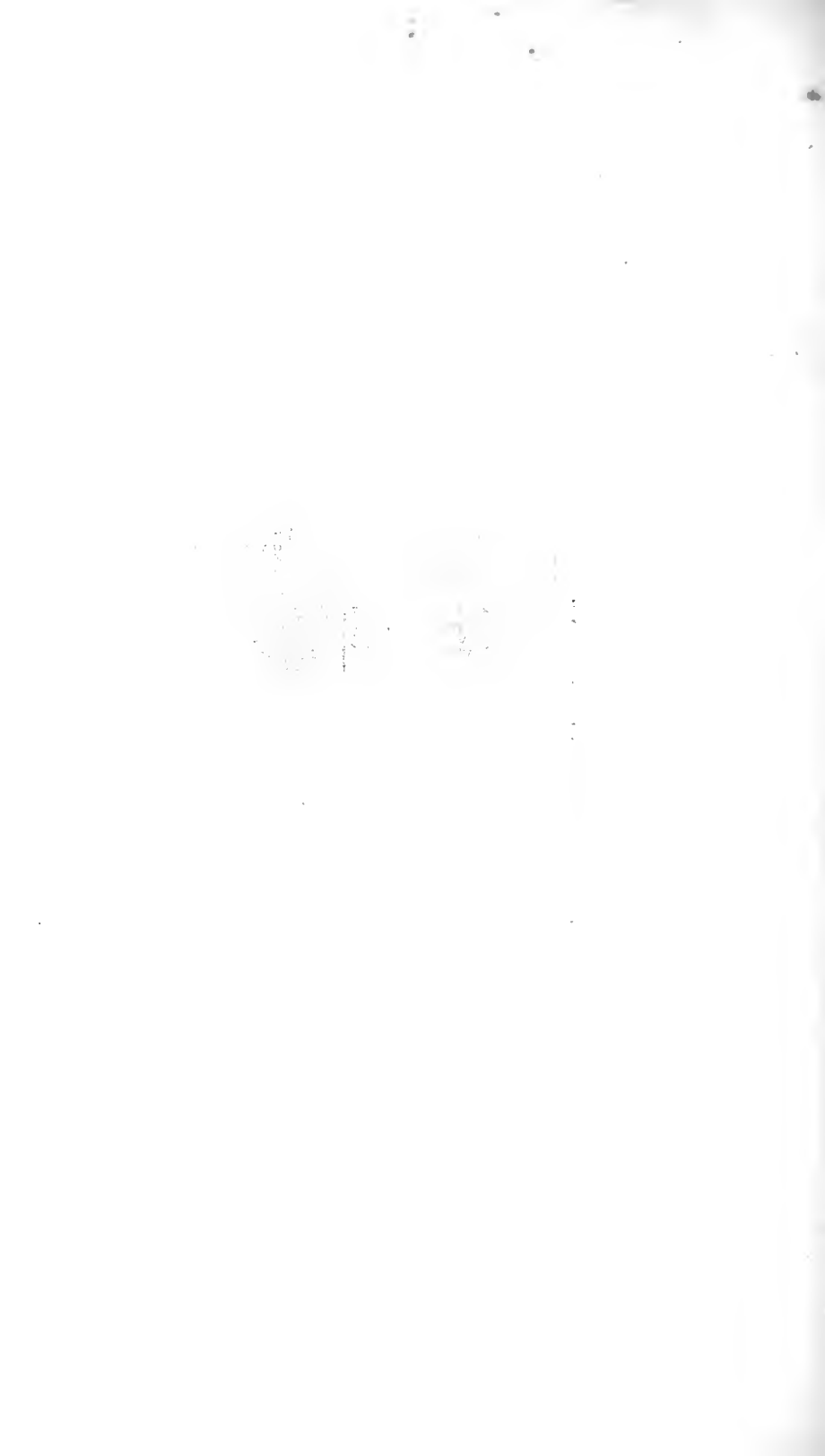
PLAN OF SECOND STORY.

1. Porch. 2. Parlor. 3. Library. 4. Parlor. 5. Dining Room. 6. 7. Passage Way. 8. Kitchen. 9. Piazza. 10. Pantry. 11. Passage Way. 12. Sleeping Room. 13. Hall. 14, 15, 16, 17. Sleeping Rooms.

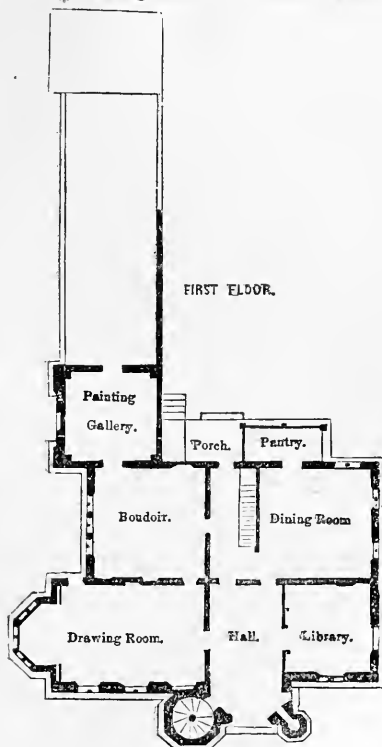


BYZANTINE COTTAGE.





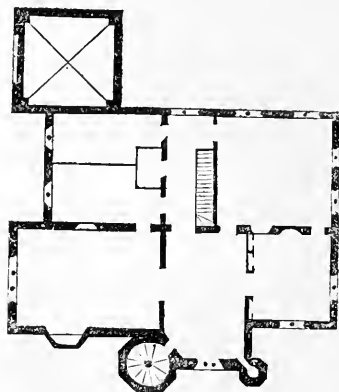
The **GOthic SUBURBAN RESIDENCE** is situated at the corner of Fifth avenue and Thirty-seventh street, New York, and is the residence of W. H. C. Waddle, Esq. The architect was A. J. Davis, Esq., of New York. The location is on one of the highest portions of New York city, the view from the tower taking in a wide and extensive prospect



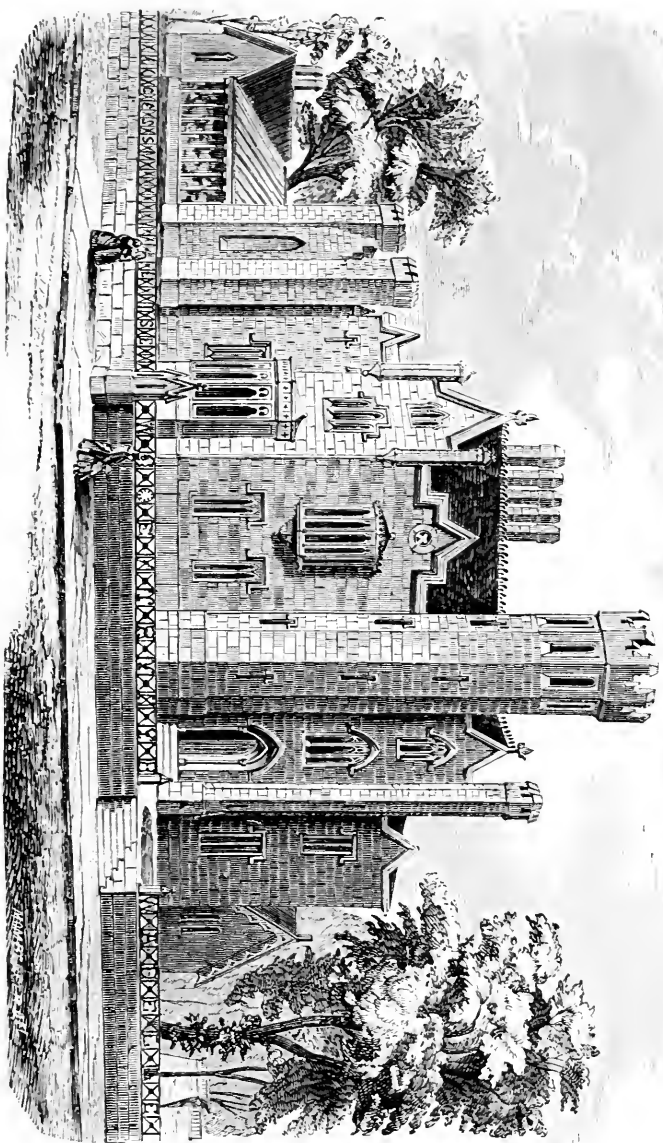
Two or three blocks to the north is the Croton Water Distributing Reservoir, covering nearly four acres; immediately adjoining is the New York Crystal Palace and the Latting Observatory; at the north is Mount Vincent, with the Catholic institutions, Mount Morris, the Croton Water

Receiving Reservoir, covering about thirty-three acres ; the Harlem River and High Bridge, which is the Croton Aqueduct across the river; then the thriving villages and towns in Westchester county. The view also takes in Long Island Sound, Hell Gate, Blackwell's Island, with all the city buildings—the East River on one side and the North River

SECOND FLOOR.



on the other ; New York Bay, filled with ships, steamers, ferryboats and small craft ; the Narrows and the broad ocean ; Staten Island, with its farms and towns ; Governor's Island, with its fortifications ; and still further on, Fort Hamilton, the cities of Brooklyn, Williamsburgh, Jersey City, Newark, and numerous towns ; the Palisades of the Hudson, and the railroads branching into the city. In addition to this, the city is, as it were, at the feet of your observation. Notwithstanding the height of the house, the Croton water is supplied in the first and second stories. Since the engraving has been made, the streets have been lowered around the house, giving to it a more isolated appearance, and vines are creeping around the tower, as they should around every Gothic tower, in order to make it



SUBURBAN GOTHIC VILLA.

[See p. 319.]



effective. The trees cover the architectural beauty, making it more rare—and by the operation of a universal law, more bewitching and enticing than if it appeared exposed. It were then repulsive—now it is fascinating.

## CHAPTER XXI.

## THE ARTIST'S AND ARTISAN'S CALLING.

RELYING upon the history of the past, a common error is taught, that pure morals and sound politics are, during the XIXth century, to be promoted by the same means that were adopted in the Ist or XIth centuries. There was a time when the destinies of Rome were swayed by the eloquence at the Forum. The political action of the State—nay, the very construction of the State itself—was indicated by the eloquence of the orator. He was then the Master—the ruling spirit; he controlled Senates—he made kings—he undone them—he exiled them. The Inventor has, by the production of the printing press, banished the Forum and the Tribune—and the editor, quiet and alone in his sanctum, writes down his thoughts, his ideas and his sentiments, and in a few hours they are read and considered by thousands—often by hundreds of thousands. The excitement and turmoil of the crowded audience no longer need exist. He who, by nature and his own will, is constructed for ruling the masses, can be heard through the public press, his voice reaching the firesides of the people, and his plans and arguments receiving the calm, quiet, dispassionate consideration of his fellow-citizens. Guizot, Lamartine, Girardin and Ledru Rollin, who for years ruled the French, had a far greater influence from their editor's chairs than from the Tribune.

These noisy, dangerous, contaminating gatherings, though less dangerous in this age than others, are being done away. Even amusements, by the inventor's arts are transplanted from the opera and the theatre, with their usual dangerous attendants, to the parlor and the social circle. The invention of the piano forte, and its kindred instruments, render



the performance of Handel's, of Haydn's, or of Mendelssohn's most difficult compositions, a usual accompaniment of the fireside—the sick wife and the prattling children, all are cheered by the music which once was only to be heard in the crowded theatre.

Not only in man's social relations has the Inventor and Artisan worked a revolution, but their power in the political world is still greater than that of the so-called statesman. The needle, the press, the telegraph, and the steam engine, have caused *intercourse among nations*, and intercourse has begot democracy, fraternity and peace. The magnetic needle was used as the unerring finger which pointed the mariner over the trackless and unbounded ocean—opening the new to the old world. The printing press was the bearer and the preserver of thought and intelligence between man and his brother—by the telegraph, the mind of the East flashes to the West faster than travels the day—the steam engine does man's labor, it bears his burdens over land and sea, and causes men to mingle with their fellow men. By all these inventions, the interests, the property, the rights, the feelings of nations are bound up and commingled with each other. Under such circumstances, war is suicide—peace is becoming a necessity—"good will toward men" the universal sentiment. But the inventor stops not here. In some European countries the statesmen turn beseechingly to "men of science," and say, "Tell us how to raise more grain on less soil, else our people will starve." No longer must the wise man be a "king's fool," and the Artist a nobleman's plaything—they now rule. The man of science tells the statesman how to raise more grain on less soil. The people need not starve.

The cotton gin and the spinning jeany have made tracts of land valuable which otherwise might still have been barren wastes—has caused thriving and populous cities to spring up on "stony places," and made fleets of vessels bedeck

the seas with their white sails, carrying on the commerce of empires.

The world has often been struck with amazement and awe at the boldness, energy and success of Napoleon going over the Alps, with his armies, to cross swords with those of the trans-Alpine countries—how much more noble is that of the civil engineers and artisans of the present day, who, like the Turks of old, seeing no other way,

“Hew one in the rock,”

and go—not over—but *through* the Alps, not to cross swords, but to bind the States together with bars of iron—the rail—to put them under bonds to keep the peace.

In different ages some peculiar feature has been dominant—we have had the age of poetry, of arms, of theology—each has shown out in resplendent lustre. In each of those ages man's condition has been improved and his nature elevated by the practice of the peculiar feature which distinguished the age. During the Poetic Age, by poetry—during the Heroic Age, by arms and conquest—in the Theological Age, from the pulpit, the lectern, and the altar. From each of these periods, great names shine on history's page, as poets, heroes, and fathers of the church. Each, in his day and generation, was great, because he practised that which, at the time, was the greatest means of helping man onward and upward.

The artist's calling in this age is to erect, with such beauty, fitness, order, and propriety, not only Houses but HOMES for the people; so that he will be frowned down as a sacrilegious villain, who would lay upon it rude hands—nay, ere long the law itself will protect it from desecration, from the hand of the despoiler; even though the owner may be a bad paymaster or a drunkard, it will not tear the wife and the children from the perfect home. It is for the artist to decide when that day shall come. The despoiler of beauty is contemned and punished by the law of man's godlike na

ture, and by the statutes of the land—so shall the Homes reared by the artist, which develop the beauty of perfection, be held sacred; and so shall its despoilers be punished. Not now, but when the artist shall rise up to the dignity of his calling, and become the ruler of the world. Then the possessor of a Home shall have in it an inalienable interest for himself and his children; then the song of “Home, Sweet Home,” shall, from all the people’s hearts, go up from homes blessed with the fruition of earthly joy, and not from those only who *have no home*, except in the memories of the past or the hopes of the future, but seek tearful relief from the thought in the consoling melody of song.

We have seen the Inventor and Artisan rising above the poet, the orator, the statesman, and the moralist, causing men from necessity to practise that brotherhood of which the poet sang, the orator spake, and for which the priest prayed. Take the single article of soap; its manufacture to any extent is recent—it created a demand for palm oil, and that demand did as much as English philanthropy to abolish the slave trade. The negro was needed to collect the oil, and the oil would sell better than the negro. The Artisan constructs ships to carry the preachers of religion to the furthestmost corners of the earth—he tells them how to do the greatest good with the least means, builds the temples with beauty, fitness and propriety, and, in the practice of his art, spreads life, liberty and happiness throughout the earth. He prints the Bible so that the blind may read; the puniest arm, by his mechanism, can lift the ponderous capstone on the pyramids; the eye, so weak that it can scarcely see the morning paper by the telescope’s aid, in the twinkling of an eye can travel out in the realms of space, taking in its range myriads of worlds; the weak eye, in a flash, rivals the beauty of a star so far distant that it took light itself years to travel from it to the earth. The thunders of the Vatican, which once rent nations in twain, are now lost in air; and the steaming, snorting locomotive—the emblem of

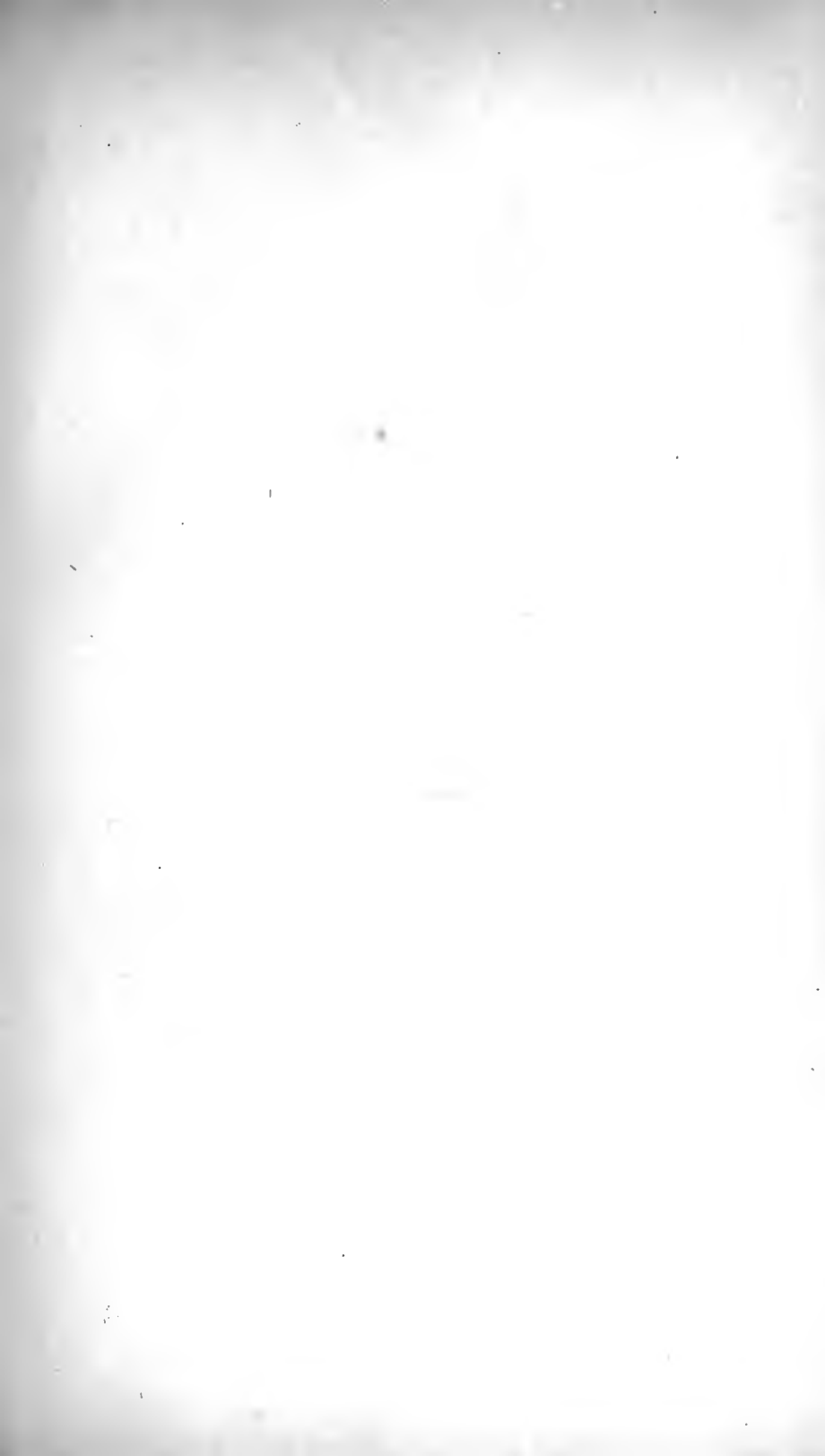
intercourse, the bearer of commerce, the causer of comfort, of plenty and peace—is more powerful than they.

The pœan of the in-coming millennium is being sung, the strains of the poet, the persuasions of the orator, the chantings of the priest, are heard; but over all and above all arises the tenor of the song, the clear, pellucid ring of the Artisan's hammer, which shall swell louder and louder, till

“The loud requiem of the world shall swell,”

when, in harmonious numbers, it shall chime in and be lost in the songs of those who chant the seraph's lay around the great white throne of the Father.

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